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ABSTRACT

This report was prepared by the National Research Council, at the request of the National Institutes of Health, in an attempt to evaluate the Graduate Research Training Grant Program and Fellowship Program in bioscience. One of the purposes of the study was to collect objective data that would provide answers to such questions as: What have been the patterns of the National Institute of General Medical Sciences (NIGMS) support to bioscience departments by academic field, by geographic region, and by type of institution? What have been the effects of this support on PhD production? In addition to supplying objective data, the report includes an evaluation of the findings and a set of recommendations to the NIGMS regarding future policies for the training programs. The report also includes an appendix on the history of federal government support for research and training in the biomedical sciences. (BB)

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EFFECTS OF NIGMS TRAINING PROGRAMS ON GRADUATE EDUCATION IN THE BIOMEDICAL SCIENCES

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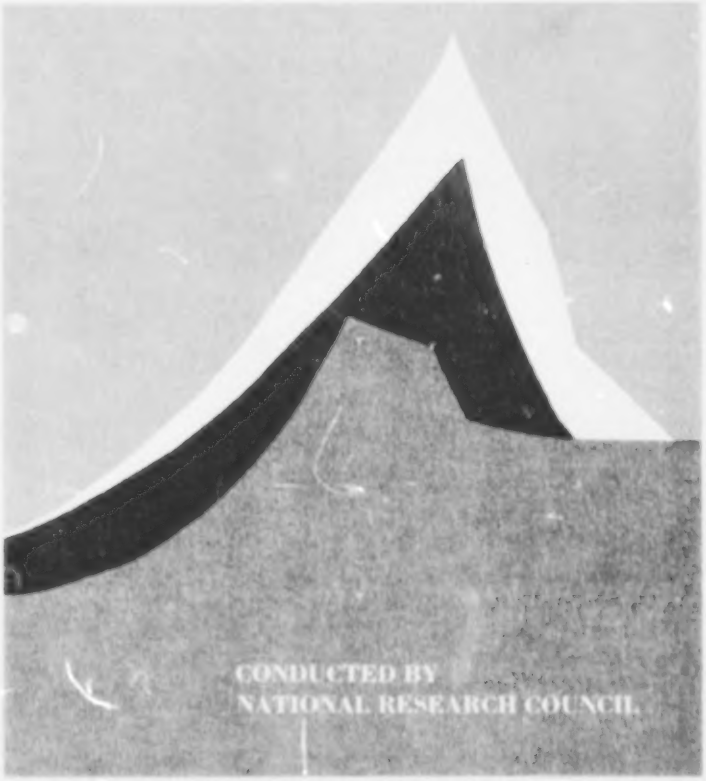
EFFECTS OF NIGMS TRAINING PROGRAMS ON GRADUATE EDUCATION IN THE BIOMEDICAL SCIENCES

AN EVALUATIVE STUDY OF THE TRAINING PROGRAMS OF THE NATIONAL INSTITUTE OF GENERAL MEDICAL SCIENCES 1958-1967



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PREFACE

Since 1958, the National Institute of General Medical Sciences (formerly the Division of General Medical Sciences) of the National Institutes of Health has provided support to graduate education in the biomedical sciences in the United States through a Graduate Research Training Grant Program and a Fellowship Program. At the request of the institute, the National Research Council (NRC), through its Office of Scientific Personnel, carried out an independent evaluative study of these programs for the period 1958 to 1967. The present report summarizes the results of the study, which has been in progress since 1965.

One of the purposes of the study was to collect objective data that would provide answers to such questions as: What have been the patterns of NIGMS support to bioscience departments by academic field, by geographic region, and by type of institution? What have been the effects of this support on PhD production? What have been the patterns of NIGMS support to graduate students? What have been the effects of this support to graduate students? What have been the effects of this support on the percentage of students attaining the PhD, on patterns of post-training employment, and on the quality and amount of research accomplished?

In addition to supplying objective data, the report was to include an evaluation of the findings and a set of recommendations to the NIGMS regarding future policies for the training program. Here the services of an Advisory Committee composed of biomedical scientists and educators were of critical importance. Such services were given generously and effectively. The members of the committee were:

John A. D. Cooper, *Chairman*, Northwestern University
H. Orin Halvorson, University of Minnesota
Harold J. Blumenthal, Stritch School of Medicine, Loyola University
Peter C. Nowell, University of Pennsylvania
Gerhard W. E. Plaut, Rutgers, The State University
Fred M. Snell, State University of New York at Buffalo
Wilson S. Stone (deceased), University of Texas
Daniel C. Tosteson, Duke University Medical Center

The Advisory Committee members suggested areas for study, reviewed the data that had been collected, evaluated the findings, and formulated the recommendations.

Members of the staff of the Office of Scientific Personnel compiled the data, carried out extensive tabulations and analyses, provided statistical summaries, and in other ways assisted the committee. Fred D. Boercker, Director of Education and Employment Studies, Office of Scientific Personnel, was the chief staff officer for the project during its culminating phase. He was assisted by Herbert Soldz, Manager of the Data Processing Section; Clarebeth Maguire, Manpower Publications Coordinator; Catherine C. Roberts, Administrative Secretary; George Boyce, Senior Programmer; and Doris E. Rogowski, Supervisor of Coding and Secretarial Services. Lindsey

R. Harmon, Director of Research, directed the project in its early phases and provided helpful advice throughout its lifetime. Stanley F. Bolin, Research Psychologist, was responsible for much of the early planning and helped significantly to shape the study. Joseph C. Boyce, Deputy Director of the Office of Scientific Personnel, followed the work closely and expedited it in many ways.

In addition, David R. Briggs, Department of Biochemistry, University of Minnesota, and Louis P. Hellman, Maryland Regional Medical Program, served as professional consultants to the study. They aided in technical planning and in assembling records and data.

Within the National Institute of General Medical Sciences, the staff officers most closely associated with the study were J. H. U. Brown, Assistant Director for Operations; Solomon Schneyer, Chief, Program Analysis Branch; Trygve W. Tuve, Chief, Research Training Grants Branch; and Robert H. McCauley, Deputy Chief, Research Training Grants Branch.

Dr. Schneyer was Project Officer for this study, and he was especially helpful in supplying basic data and study documents from NIGMS to the Academy staff.

It is hoped that the study was successful in obtaining answers to the questions posed and that this report will be of use both to the academic community and to the sponsoring agency. Areas of program success have been identified as well as areas where change seems desirable. The descriptions, evaluations, and recommendations contained here will have served their purpose if they result in recognition that much has been accomplished, but that much remains to be done in achieving the nation's health goals through improved biomedical education.

John A. D. Cooper
Chairman, Advisory Committee
Study of Research Training Grant Programs

William C. Kelly
Director, Office of
Scientific Personnel

March 14, 1969

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HIGHLIGHTS

SUMMARY OF FINDINGS
SUMMARY OF RECOMMENDATIONS

Summary of Findings

- The Graduate Research Training Grant Program of the National Institute of General Medical Sciences (NIGMS) provides support for graduate student stipends and tuition and for strengthening the departments in which graduate training is given. Bioscientists with graduate research training of this kind are needed by society to:

  continue the contributions of research in providing a rational basis for the maintenance of health;

  provide staff for medical school departments to increase physician manpower to meet rising expectations for the delivery of health care; and

  provide faculty for the expanding bioscience enrollments of colleges and universities.

- In providing authority for support of research training, the Congress recognized the importance of an adequate number of biomedical scientists to meet the nation's needs. In 1958 the Division of General Medical Sciences was formed within the National Institutes of Health, and in 1962 the division was raised to "institute" status as the National Institute of General Medical Sciences. The NIGMS was to "conduct and support research training in the general and basic medical sciences and related natural or behavioral sciences." The Research Training Branch was to strengthen research institutions and assist in the research training of competent graduate students.

- In 1965, 30 percent of the pre-PhD bioscience graduate students received NIGMS training and fellowship grants. These grants accounted for approximately 26 percent of all stipend support and 16 percent of the total income for these students during 1965.

- Projection of future manpower requirements is dependent on the nature of the assumptions made about key variables. Unassailable quantitative projections of future need for bioscientists do not exist, but the qualitative assessments of national committees and the quantitative studies that are available all indicate a need for more research doctorates in the biosciences during the coming decade than are now being produced. The existing quantitative studies show the projected supply of doctorate-holding bioscientists to be about half the projected demand.

- The number and the quality of students in the undergraduate bioscience "pipeline" seem adequate to support a marked increase in the percentage continuing to the PhD without lowering quality.

- The recent rapid growth of bioscience enrollments at the undergraduate level, coupled with the less-than-average growth at the doctorate level, indicates a less-than-adequate number of well-qualified college and university staff available to teach the expanding undergraduate classes.

- NIGMS support for graduate training in the biomedical sciences through traineeship and fellowship programs varies by academic field. The amount of stipend and dependency support, the percentage of doctorate-granting departments having NIGMS trainees, and the median total months of support supplied to students all reveal a great deal of variation among the different bioscience fields.

- Regional distribution of NIGMS funds and graduate student support, when compared with bioscience PhD production and graduate student enrollment, showed the New England and Middle Atlantic states receiving proportionately more than the West North Central, West South Central, and Mountain states. Likewise, private institutions received proportionately more NIGMS support than public ones. (It should be noted that balanced geographical distribution was not a goal of the research training programs.)

- Comparisons between departments having NIGMS training grant support and departments in matched fields without such support show that:

  1. The gain in average PhD production per department between 1958-1962 and 1963-1967 was markedly greater for the NIGMS-supported departments than for nonsupported ones; smaller departments show the greater percentage increases in PhD production as a result of NIGMS grants, but larger departments show comparable gains in absolute numbers of doctorates granted.

  2. Full-time graduate student enrollment in biochemistry departments with NIGMS support increased much more rapidly than corresponding enrollment in biochemistry departments without support (1960 to 1965). Nonsupported fields (botany and zoology) in the same institutions did not show these differences.

  3. The number of PhD-granting departments in the biosciences increased by one third during the decade covered by the study. Not all these differences should be attributed directly to NIGMS training grant support, but training support was a major factor enabling recipient departments to grow as rapidly as they did.

- Anecdotal reports of training grant program directors and the personal experience of the members of the Advisory Committee for this study indicate a positive effect of the training grants on faculty, curriculum, and physical facilities. Faculties have been increased, new courses have been offered, and important items of equipment have been obtained through training grant support. Thus, in addition to producing more PhD's, the training grants seem to have strengthened the training departments, although the effect is difficult to quantify.

- A total of 28,563 persons received NIGMS training support in the period 1958-1967. Of these, 23,380 were "trainees only"; 3,759 were "fellows only"; and 1,364 received both traineeship and fellowship support. After a period of initial growth, the number of NIGMS-supported trainees and fellows leveled off in 1965 at approximately 7,700 and 1,100 per year, respectively.

- The typical pattern of support was to use traineeship funds to support the student during his first one or two years of graduate work and then to

shift him to some other form of support such as an NIGMS fellowship or, perhaps, a research assistantship, for the remaining two or three years until he completed the PhD.

- During the course of their graduate study, the NIGMS-supported students did receive support from other sources, but they were much less likely to be dependent on their own earnings or on research assistantships than non-NIGMS-supported bioscience graduate students.

- The baccalaureate-to-PhD time lapse for NIGMS trainees and fellows was one to two years less than for non-NIGMS-supported doctorate recipients in matched fields and from matched graduate departments.

- The PhD-attainment rate for NIGMS-supported students compared favorably with rates reported for other programs in the few similar studies available. About 50 percent of the pre-PhD "trainees only" ultimately attained the PhD; 80 percent of the "fellows only" attained the degree, and 85 percent of the "trainee-fellows" received PhD's. This compared with a 76 percent attainment rate for all National Science Foundation bioscience fellowship awardees who were first-year graduate students in 1955 and 1956 and a 45 percent attainment rate for National Defense Education Act (NDEA) fellowship recipients of the period 1960-1963.

- The NIGMS training program drew heavily for student input from baccalaureate majors in chemistry and other nonbiological sciences. However, most trainees (59 percent) who received PhD's indicated their PhD field to be the same as the training field.

- A larger proportion of doctorate recipients with NIGMS support assumed immediate postdoctoral research fellowships than did those without this support but from the same group of departments.

- As the doctorate-recipient group gains professional maturity, it performs more diversified functions. By 4-7 years after the doctorate, the proportion of former NIGMS trainees engaged primarily in research (including postdoctoral fellowship research) dropped from 76 percent to 57 percent. The percentage in administration and in teaching increased.

- Forty-five percent of the trainees who did not attain the PhD found employment in universities or hospitals and were engaged in health-related activities. The training programs are therefore contributing skilled persons to the biomedical manpower pool in addition to those who attain the doctoral degree.

- Doctorate recipients supported previously by NIGMS training grants produced, on an average, more publications of higher quality (as judged by the number of citations to their work in the literature) than those without NIGMS support and from matched graduate departments.

SUMMARY OF RECOMMENDATIONS

- Recommendation: Although the rapidly changing character of graduate education hampered evaluation of the effects of the Graduate Research Training Grant Program on total bioscience PhD production, the program did have measurable positive impacts on the departments and on the students. The program, therefore, should be continued.

- Recommendation: The number of students supported annually by the NIGMS training grants should be determined by the national need for high-level bioscience manpower. Until wide-ranging studies of societal need for such manpower for research, teaching, and administration can be completed, it is recommended that the results of recent studies be accepted to establish temporary manpower goals. These available studies suggest that the annual rate of bioscience doctorates should be increased—perhaps doubled—to meet future requirements.

- Recommendation: The stipend level for pre-PhD NIGMS trainees should be increased. An initial increment of 25 percent should be made, and thereafter stipends should be related to the cost-of-living index.

- Recommendation: A cost-of-education allowance equal at least in amount to the stipend allowance should be provided by NIGMS to be used in improving the research training capability of the department.

- Recommendation: The present NIGMS policy of utilizing peer judgment by competent bioscientists in the selection of review and advisory committees should be continued. However, broader representation of the bioscience professional community should be sought in such consultation.

- Recommendation: It should be possible to move students on and off training grants as local conditions demand. Any student who has been supported *at any time* by the training grant should be credited to the training grant program when evaluating the effectiveness of the program.

- Recommendation: Present NIGMS policies, which (1) emphasize predoctoral training; (2) attempt to balance support between on-going programs and new programs in departments where quality can be developed; and (3) continue departmental support for new programs for a minimum of five years, are effective and should be continued.

- Recommendation: The NIGMS Graduate Research Training Grant Program should have among its goals that of providing an opportunity for the educationally and culturally disadvantaged to pursue careers in biomedical research. It should be recognized that such students may require more support than currently enrolled students. Such programs should be evaluated carefully to see that they have attained their stated objectives, making allowances for the beginning level of the students.

- Recommendation: Periodic evaluation of the NIGMS training program is desirable. Future evaluation would require the continued collection of data describing the various aspects of the program, including quality aspects, as objectively as possible. However, there will continue to be a need for expert subjective evaluation of these programs.

CHAPTER I

INTRODUCTION

NATIONAL GOALS FOR BIOMEDICAL EDUCATION

FEDERAL PROGRAMS

GRADUATE EDUCATION IN THE BIOSCIENCES

- Numbers of Doctoral Bioscientists
- Graduate Enrollment and PhD Production
- Undergraduate Supply
- Types of Support

SUMMARY

The Graduate Research Training Grant Program of the National Institute of General Medical Sciences (NIGMS) provides support for graduate student stipends and tuition and for strengthening the departments in which graduate training in the biomedical sciences is given. Training grants are designed to increase the number of research-trained bioscientists and to enhance the quality of their education. These scientists are needed both to achieve the biomedical research goals of the nation and to provide an important source of faculty for the expanding enrollments of colleges, universities, and medical schools.

The immediate purpose of this study was to collect and analyze data that would describe objectively the accomplishments of the NIGMS traineeship and fellowship programs during the past decade. This information was, in turn, to provide a basis for recommendations concerning policy decisions affecting these programs. However, the study has broad implications for biomedical education in the United States and for its contributions to national needs. The period covered by the study was one of rapid expansion of higher education, especially graduate education; it was one of rapid change in national goals for science; and it was a period in which the emphasis of Federal support to graduate education began to change radically, including changes in fellowship and traineeship support. The recommendations growing out of this study are based on the evaluation of the accomplishments of the NIGMS training programs over the past decade, and also on the projections of the needs and functions of these programs in the coming decades. It is first necessary, therefore, to examine the national goals toward which the training programs have been directed and to become aware of the milieu within which they have operated.

NATIONAL GOALS FOR BIOMEDICAL EDUCATION

Biomedical scientists perform a wide variety of functions, and they provide society with many critically needed services. Among the most important of the societal needs served are: (1) contributions of biomedical research, not only in acquiring a better understanding of living systems and disease and providing a more rational basis for the maintenance of health, but also in the improvement of man's environment. (This research is at the cutting edge of modern science. It is an undertaking with great social relevance.); (2) staff for schools of the health professions to permit them to increase the manpower needed to meet society's rising expectation for better health care; and (3) faculty for teaching the rapidly expanding numbers of students of the biosciences in colleges and universities.

Every national assessment of health needs in the United States has identified traineeships and fellowships as important mechanisms for increasing the quality and quantity of research-trained bioscientists to meet these needs. The following statements from committee reports support these views.

- Report of the Committee of Consultants on Medical Research to the Subcommittee on Departments of Labor and Health, Education, and Welfare (1960):[1]

  The Committee of Consultants began its review of the Federal program in support of medical research with certain assumptions which it found to be sound on the basis of information obtained and the opinions heard in the course of its survey. These assumptions have now become firmly held convictions.

  (1) The health of the people is the greatest resource of the Nation, absolutely vital to its welfare, economy, and security.

  (2) The present state of the Nation's health, although greatly improved since the beginning of the century, is still far from the goal of assuring that as many of our population as possible live full and active lives, not warped or blighted by disease. . .

  (3) The only way we can hope to lessen this burden in the future is through progress in medical research and the practical application of research findings.

  (4) Medical research has already proved its value in both humanitarian and economic terms. . .

  (5) The American people have demonstrated through their Congress and through their private voluntary contributions that they consider it essential and urgent to support a determined attack on the dread diseases through research.

  (6) The magnitude of that attack and the program of medical research to be supported will be determined by the degree of urgency felt by the people of the United States in obtaining answers to the problems of prevention and treatment of serious disease. The Committee believes the urgency is such that it can be satisfied only by the maximum utilization of the medical research potential of the country, as well as the contributions of competent investigators abroad.

  The research grant, training grant, and fellowship programs of the National Institutes of Health over the past 15 years have constituted the most important single force in raising the standard of medical research, teaching, and practice in the United States to its present high level. It is of paramount importance that these programs receive support in proportion to the rate of growth anticipated.

[1] U.S. Congress, Senate, *Federal Support of Medical Research*, 86th Cong., 2d Sess., May 1960 (Washington: U.S. Government Printing Office, 1960), Introduction, pp. xxv, xxvi.

- The President's Commission on Heart Disease, Cancer and Stroke (1964):[2]

  Many factors combine to increase the demand for additional manpower across the entire range of the health sciences. The expanding population, the rapid growth of its aging component, and other social forces are creating demands for medical care far beyond the present capacity of practicing health professionals. The swift growth of biomedical sciences creates parallel demands for increasing numbers of highly trained scientists. Moreover, developments in both research and the practice of medicine have led to the creation of new technical and supportive disciplines—essential to high-quality work—which are in very short supply.

  The education of a physician or a research scientist requires many years. This long lead time precludes overnight attainment of manpower goals. But action now is essential if we are not to drop still further behind. Faced with overwhelming needs and inadequate resources, the Commission recommends programs of intensive effort for manpower development.

  Research is conducted by the minds of trained scientists. It is in the national interest, therefore, to insure a continuing and expanding supply of biomedical scientists adequately trained to guarantee the quality of health research tomorrow.

  The funding instrument most suitable to the task of assisting the university, or other research-educational organization, in providing such advanced training is the "training grant." This instrument permits local identification of young men and women with research potential, provides them with appropriate stipends and, equally important, by diverse means assists the institution to improve the quality of research training while enlarging its capacity for so doing.

- Report to the Committee on Science and Astronautics, U.S. House of Representatives, by the National Academy of Sciences (1965):[3]

  The biomedical sciences are concerned with man. Their objectives are elimination of abnormalities, prevention or cure of diseases, and prolongation of lives.

  More students of high intelligence and promise are needed in both PhD and MD educational programs. Additional Federal support for doctoral education and post-doctoral training is recommended.

- A Report to the President on the Research of the National Institutes of Health (1967):[4]

  In the long run the state of health in this country and the individual citizen's prospects for a long and productive life depend on the initiative and imagination with which our scientists and research workers pursue the advancement of knowledge and the conquest of obstacles that bar its fullest utilization. Thus the basic strategy of our Federal health effort is to emphasize those activities, such as research, which, in the long run, will improve in a fundamental way the health prospects of the Nation.

[2] *A National Program to Conquer Heart Disease, Cancer and Stroke*, I (Washington: U. S. Government Printing Office, December 1964), Part ii, Chapter vi, p.53.

[3] *Basic Research and National Goals* (Washington: U.S. Government Printing Office, 1965), p.111.

[4] U.S. Department of Health, Education, and Welfare, July 1967, *The Advancement of Knowledge for the Nation's Health* (Washington: U.S. Government Printing Office), Letter of transmittal of the report to the President.

TABLE 1

Number of Biomedical Scientists with PhD Degree in Research and Teaching (1960 and 1965) and Predictions for Future Needs (1970 and 1975)

	Number of Biomedical Scientists with a PhD Degree			
	1960 (Actual)	1965 (Actual)	1970 (Projected) [a]	1975 (Projected) [a]
TOTAL	**16,000**	**20,400**	**28,000**	**38,500**
MEDICAL SCHOOLS				
Basic Science Departments	4,100	5,500	7,300	9,700
Clinical Departments	1,800	2,200	3,000	4,500
New Medical Schools	---	---	1,000	1,600
DENTAL SCHOOLS (RESEARCH)	700	900	2,100	3,000
VETERINARY, PUBLIC HEALTH, AND PHARMACOLOGY SCHOOLS (RESEARCH)	600	1,000	1,600	2,100
NONMEDICAL SCHOOLS (TEACHING BASIC SCIENCES)	3,100	3,800	4,400	5,900
NONACADEMIC INSTITUTIONS	5,100	6,200	7,200	9,800
SUPPORT FOR HEART DISEASE, CANCER AND STROKE, AND REGIONAL MEDICAL PROGRAMS	---	---	200	500
ATTRITION	600	800	1,000	1,400

[a] *Data for 1970 and 1975 and projections based on 1960-1965 increments.*

Source: *Brown and Stone,* The Journal of Medical Education, *XLII, No. 6 (1967).*

Each of the above statements implies a need for increased numbers of biomedical scientists if national health care requirements are to be met. Can the magnitude of this need be quantified? Projection of manpower requirements is an uncertain and perilous process, wholly dependent on the nature of assumptions made about trends in a series of key variables.

One estimate of the magnitude of the need for biomedical research manpower has been made recently by Brown and Stone.[5] (See Table 1.)

They conclude that:

> Calculations from these data indicate that the average annual increment required between 1960 and 1965, 1965 and 1970, and 1970 and 1975, to produce the needed biomedical personnel is 850, 1500, and 2100 individuals, respectively. In contrast, the average annual PhD production in the basic medical sciences for these 3 five-year periods is 637, 800, and 975, respectively.

The projected supply of bioscience PhD's, according to their study, is thus about half the projected need.

A second estimate of future need for biomedical manpower has been published recently by NIH.[6] The NIH "best judgment" projection (1965-

[5] J.H.U. Brown and Frederick L. Stone, "Manpower in the Basic Medical Sciences," *The Journal of Medical Education, XLII,* No. 6 (1967), p. 503.

[6] U.S. Department of Health, Education, and Welfare, *Resources for Medical Research: Biomedical Manpower for the Eighties* (Washington: U.S. Government Printing Office, 1968), p. 40.

1985) indicates a need for almost 100,000 new PhD's during the 20-year period for biomedical research.

Although not concerned primarily with bioscience manpower, the recently published report of the National Science Board[7] projects the expenditures for graduate education in the United States to rise from $7 billion in 1970 to $19 billion in 1980.

It is not within the domain of this study to evaluate the soundness of the assumptions and the resulting accuracy of the above projections. However, these are the most complete and pertinent studies available. The statistics they present all indicate a need for more bioscience manpower at high levels of education during the coming decade than is now being produced. These data agree, in turn, with the qualitative comments quoted previously. Until additional authoritative information becomes available, the present studies would indicate a need to increase the number of persons in graduate training in the biosciences.

FEDERAL PROGRAMS

Support for research and development by the Federal Government comes from the recognition of the importance of science and technology to the welfare and security of the country. Relatively little support was made available by Congress before World War I. Contributions to the country's defense by scientists during that conflict stimulated considerable governmental support of research-and-development projects, both military and civilian. Federal interest and funds for such purposes continued to increase during the postwar period of the 1920's. However, it was left largely to private philanthropic organizations to provide the major support of basic research during this period. After the depression of the early 1930's, the pattern of support gradually changed from the private to the public sector, and this trend was greatly accelerated during World War II.

Meanwhile, the scope and responsibilities of the Public Health Service (PHS), established in 1912, were broadened by Congress to include support of research training. In 1930, the Hygienic Laboratory was redesignated by an Act of Congress as the National Institute of Health (NIH). In this legislation (PL 71-251) the first authority was given for the establishment of fellowships within the NIH. The Institute was authorized to assume training responsibilities in the area of its interest.

By 1950, seven institutes had been authorized and established as components of the "National Institutes of Health." These were:

National Cancer Institute
National Institute of Mental Health
National Institute of Dental Research
National Heart Institute
National Institute of Allergy and Infectious Diseases
National Institute of Arthritis and Metabolic Diseases
National Institute of Neurological Diseases and Blindness

The authority for the support of training and instruction was rather specifically pointed to "professional training related to the cause, prevention, methods of diagnosis, and treatment" of the particular disease or group of diseases constituting the scope of activity of a particular institute. Restrictions in the responsibilities and prerogatives of the institutes arising from their "disease orientation" or categorical designations severely restricted the areas of training that could be supported by an institute. To make possible training programs and research programs that were concerned with the problems of more than one institute, and not necessarily categorically

[7]National Science Board, 1969, *Graduate Education: Parameters for Public Policy* (Washington: U.S. Government Printing Office), p. 159.

TABLE 2
Comparison of NIGMS and NIH Appropriations for Training, Fellowship, and Research Grants, Fiscal Years 1958-1967

Fiscal Year	TOTAL Grants			Training Grants			Fellowship Grants			Research Grants		
	NIH Total	NIGMS		NIH Total	NIGMS		NIH Total	NIGMS		NIH Total	NIGMS	
	Dollars in Thousands	Dollars in Thousands	Percent of NIH	Dollars in Thousands	Dollars in Thousands	Percent of NIH	Dollars in Thousands	Dollars in Thousands	Percent of NIH	Dollars in Thousands	Dollars in Thousands	Percent of NIH
1958	177,376	11,466	6.5	32,932	500	1.5	6,440	1,498	23.3	97,729	9,468	9.6
1959	242,539	25,921	10.7	49,902	6,040	12.1	10,408	3,260	31.3	141,454	16,621	11.8
1960	334,430	41,907	12.5	74,673	13,038	17.4	14,570	5,310	36.4	202,948	23,559	11.6
1961	470,439	79,243	16.8	110,000	27,000	24.5	22,000	10,100	45.9	306,778	42,143	13.7
1962	598,998	121,537	20.3	118,506	31,000	28.0	29,080	11,290	38.8	433,662	79,247	18.3
1963	930,800	151,343	16.3	154,139	35,442	23.0	41,638	14,480	34.8	492,805	101,421	20.6
1964	814,569	158,257	19.4	172,602	37,256	21.6	45,786	15,277	33.4	529,231	105,724	20.0
1965	875,199	158,362	18.1	181,311	37,182	20.5	48,985	16,765	34.2	545,154	104,415	19.2
1966	1,026,853	121,987	11.9	209,896	41,375	19.7	55,130	18,454	33.5	553,307	62,158	11.2
1967	1,155,337	138,314	12.0	224,486	43,735	19.5	60,123	19,400	32.3	681,197	75,179	11.0

Source: NIH Almanac 1967, *National Institutes of Health, Office of Information (U.S. Office of Health, Education, and Welfare) pp. 73-75.*

oriented, a new Division in the NIH, the Division of General Medical Sciences (DGMS), was formed by congressional directive in June 1958. It was established to promote "research and training through grants in all scientific fields basic to general medicine, aging and public health, including the clinical and pre-clinical sciences." Thus, for the first time, Congress directed the Public Health Service to support training in the basic sciences without requiring that this training be associated with a particular disease or condition.

In 1962, under PHS Act Amendments (PL 87-838), the Division of General Medical Sciences became the National Institute of General Medical Sciences. Section 301 (d) of this act stipulated that the phrase "research or research training projects" be used to replace the more limiting phrase, "research projects," contained in the original, thereby providing more explicit legislative authority for the training programs of the entire Public Health Service.

The major goals of NIGMS have been stated by its director Frederick L. Stone.[5]

> The Division of General Medical Sciences is the principal unit of the National Institutes of Health responsible for research training and fellowship programs in the fundamental biomedical and health-related sciences. These training programs are designed to help meet the requirements for training scientific manpower in the shortage areas represented by the fields basic to medicine and health, and to help meet the growing needs of the Nation's medical schools and other research institutions for academic and research personnel in both present and future faculties.
>
> The goals of the work of the Research Training Branch of the Division can be summarized as follows:
>
> To strengthen research institutions and increase their potential for training scientists;
>
> To assist in the continuing research training of competent, highly motivated students through the graduate and professional schools of the universities;
>
> To expand the opportunities for intensive training of predoctoral and postdoctoral candidates in additional research institutions wherever appropriate;
>
> To provide increased numbers of stable career opportunities for scientists of superior potential and capability in the sciences related to health; and
>
> To encourage and support the greater utilization of training manpower to improve the teaching and training functions of the universities and research institutions.

Thus the training programs are expected not only to prepare biomedical research scientists but also to provide the faculty for medical schools, colleges, and universities.

Since 1958, DGMS and NIGMS grants have constituted a major source of support for graduate students in some 30 disciplines in the basic medical sciences. Table 2 compares expenditures for such support by NIGMS and by all of the NIH. Between 1958 and 1962, NIGMS accounted for an increasing percentage of total NIH appropriations, but between 1964 and 1967, the NIGMS proportion of the total NIH appropriations decreased for both research and training grants. Although NIGMS accounted for 22 percent of the NIH *money* appropriated in fiscal year 1966 for traineeships

[5] U.S. Department of Health, Education, and Welfare, *Research Training Programs* of the Division of General Medical Sciences (Public Health Service, 1962) Publication No. 865, pp.v-vi.

and fellowships, they supported 34 percent of the *students* receiving NIH training and fellowship aid. This is partly explained by the fact that NIGMS support is largely for predoctoral students, and other institutes have more postdoctoral students with higher stipends.

More detailed historical information about Federal programs for support of graduate training in the biomedical sciences is presented in Appendix A of this report. Table A1 shows that of the 14,216 graduate and postdoctoral students in the health sciences supported by all Federal agencies in fiscal year 1967, the NIH supported 10,744, or 75 percent of these. Therefore, since NIGMS accounts for approximately one third of the total NIH effort, NIGMS funds account for approximately 25 percent of all Federal traineeships and fellowships. The only other Federal agency supplying appreciable support to the biosciences was the National Science Foundation, which supported 1,179 persons, or 8 percent of those supported by the Federal Government.

GRADUATE EDUCATION IN THE BIOSCIENCES

Biomedical scientists receive their advanced education in the graduate schools of the nation's universities. The past decade has been a period of rapid growth and change in graduate schools. These changes provide a shifting backdrop against which the effects produced by the NIGMS training program must be measured. If graduate education had been in a steady state, or in a more steady and even state of growth, it would have been much easier to evaluate the effects of NIGMS training programs on the course of development. But such was not the case.

During the ten-year period, 1958 through 1967, the number of research doctorates awarded more than doubled (Table 3). Growth occurred in each of the seven summary fields shown in the table, but the rate of growth varied. Engineering led with an average rate of increase of 17.1 percent per year, almost double that for all fields (9.8 percent per year). The physical sciences, arts and humanities, professional fields, and education increased at about the average rate of 10 percent per year, and the social sciences and biological sciences experienced an 8 percent per year increment.

Although the growth rate in doctorate production for all biological sciences combined was somewhat below average, examination of the fields within the biosciences reveals a great variety in growth rate for individual disciplines. The newly emerging field of biophysics shows the most dramatic rate (almost 19 percent per year). Older fields, such as anatomy and physiology, which have developed new and exciting approaches in their research, have had a renaissance in recent years. Recognition of the importance of knowledge about large biological systems in the face of mounting concern about our environment is attracting students into ecology. Biochemistry, even though modern in its approach, had already reached a level of maturity earlier. Botany, zoology, and the agricultural sciences have not grown as rapidly as the other biosciences.

The footnoted fields in Table 3 are those that have received appreciable amounts of NIGMS support through training grant or fellowship programs. The reader should be wary, however, about judging the effects of a training program simply in terms of these growth rates. The effect of the training program on doctorate production is really the difference between the observed growth rate with the training grants, minus the growth rate which would have resulted had the grants not been available. Biophysics very likely would have experienced an increase even without traineeship and fellowship support, but probably somewhat less than the observed 19 percent. Likewise, microbiology may have fallen even below its observed 6.6 percent rate without such support. A more careful study of the effects of NIGMS training grants on doctorate production in departments is presented in Chapter III (Figure 9, Table 10).

TABLE 3

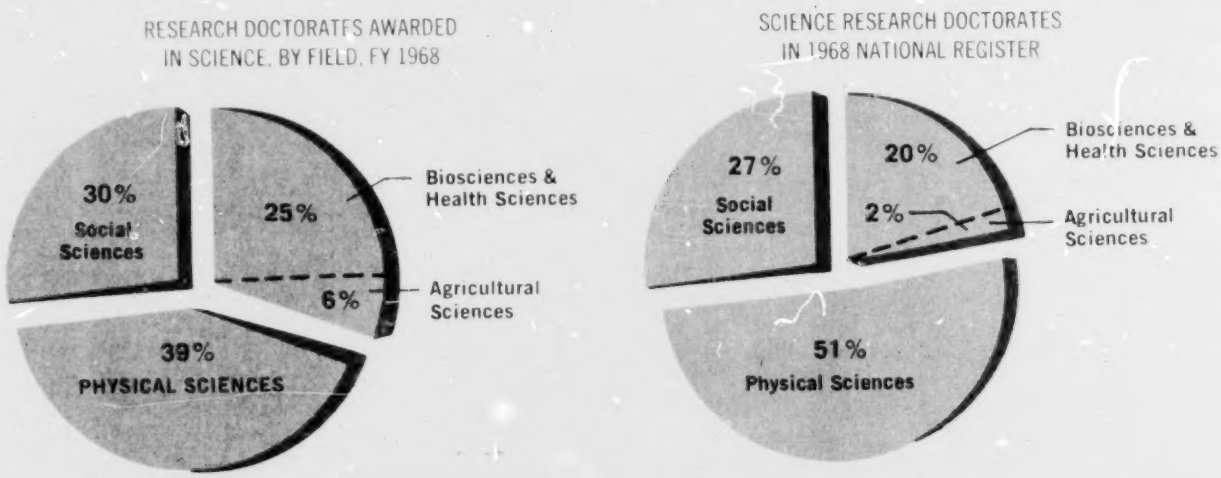
Doctorates Granted by Field, Fiscal Years 1958-1967

Field of Doctorate	Number of Doctorate Recipients, by Fiscal Year										Average Percent per Year Increase
	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	
TOTAL All Fields	**8,770**	**9,212**	**9,734**	**10,411**	**11,507**	**12,720**	**14,324**	**16,302**	**17,865**	**20,295**	**9.8**
EDUCATION	1,489	1,552	1,547	1,680	1,898	2,130	2,348	2,727	3,026	3,442	9.9
PROFESSIONAL FIELDS	326	337	368	368	444	504	546	584	730	834	11.2
ARTS & HUMANITIES	1,218	1,272	1,448	1,495	1,562	1,663	1,984	2,324	2,497	2,859	10.0
SOCIAL SCIENCES	1,598	1,680	1,697	1,821	1,928	2,078	2,304	2,377	2,666	3,157	7.9
PHYSICAL SCIENCES	1,888	2,090	2,152	2,325	2,484	2,912	3,117	3,543	3,794	4,306	9.7
ENGINEERING	629	699	792	940	1,215	1,357	1,662	2,068	2,283	2,581	17.1
BIOSCIENCES	1,622	1,582	1,730	1,782	1,976	2,076	2,363	2,679	2,869	3,116	7.7
[a]Biochemistry	237	217	259	272	286	300	371	391	446	495	8.9
[a]Biophysics	21	23	23	25	33	36	40	54	83	90	18.6
[a]Physiology	132	139	129	133	160	207	236	270	255	312	10.7
[a]Anatomy	30	36	31	45	49	51	56	88	66	86	15.2
Entomology	93	72	95	95	102	86	105	134	128	143	8.2
[a]Microbiology	203	168	184	176	199	210	194	273	286	330	6.6
[a]Genetics	71	75	74	73	81	97	98	102	113	142	8.4
Ecology	29	20	30	32	39	45	38	34	34	55	14.4
Botany	90	92	118	116	98	108	133	144	160	131	5.3
Zoology	140	135	175	170	187	186	204	226	267	229	6.3
Bioscience, General and Other	45	44	42	34	38	41	109	109	143	168	–
Agriculture & Forestry	337	342	413	438	470	465	517	576	572	601	6.8
[a]Health Sciences	194	219	157	173	207	200	262	278	316	334	7.5

[a]These are fields which have received NIGMS support through training grant or fellowship programs. Refer to Tables 15 and 16 for the number of pre-PhD's supported by field of training between 1958 and 1967.

Source: National Research Council, Office of Scientific Personnel, Doctorate Records File.

FIGURE 1
Bioscientists as a percentage of all scientists awarded a research doctorate in fiscal year 1968 and as a percentage of all scientists with research doctorates in the 1968 National Register.



Source: National Research Council, Office of Scientific Personnel, Doctorate Records File.
National Science Foundation, Reviews of Data on Science Resources (No. 16, December 1968).

Numbers of Doctoral Bioscientists

Almost one fourth of all science PhD's granted and one sixth of all PhD's in the National Register of Scientific and Technical Personnel are in the biosciences. Excluding agricultural fields, bioscientists accounted for 12 percent of *all* PhD's granted in fiscal year 1967 and 23 percent of the total *science* PhD's for that year.[9] In comparison, the 1968 National Register of Scientific and Technical Personnel maintained by the National Science Foundation lists over 111,000 PhD scientists, and 22,344 of those (20 percent) are nonagricultural bioscientists (Figure 1).

In addition to the 22,344 PhD bioscientists, the Register includes 7,455 bioscientists with professional doctorates such as the MD. However, this total of 30,000 persons represents less than 0.3 percent of all professional workers in the United States and a mere 0.03 percent of the total labor force.

Graduate Enrollment and PhD Production

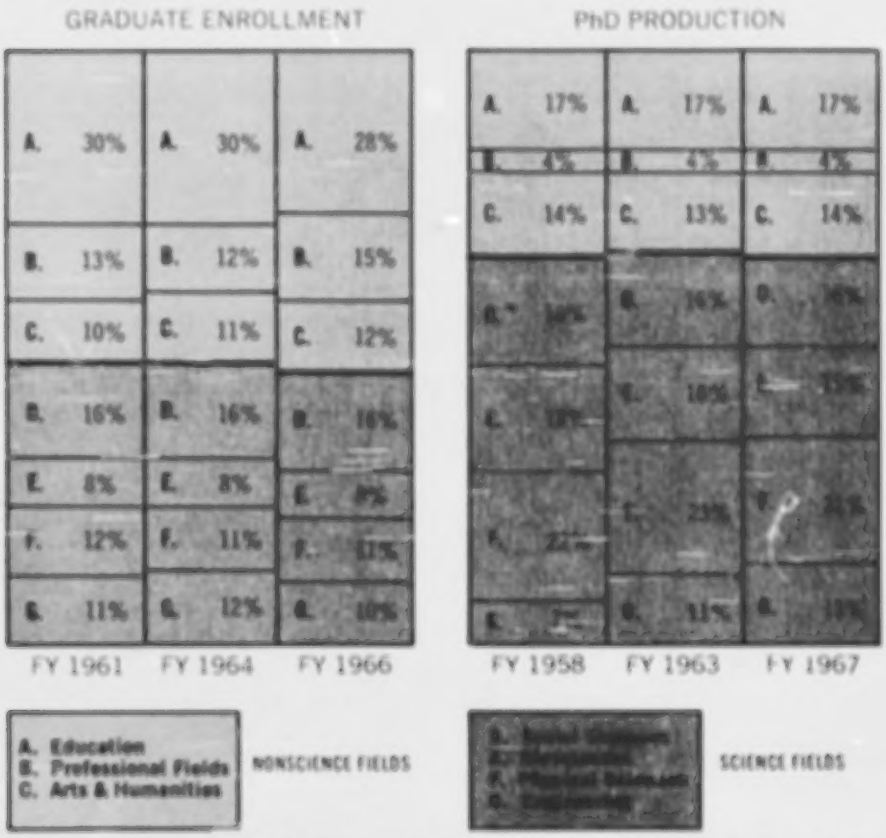
Examination of data describing trends in graduate enrollment and PhD production reveals that Federal support, which has been directed primarily to science and engineering, has not destroyed the balance among the various academic fields (see Figure 2 and Table 3).

The distribution of graduate student enrollment and PhD production has demonstrated a remarkable stability. Even though the sciences have not dominated graduate education, it does not follow that Federal support for the sciences and engineering has had no impact, but its consequences are complex and moderated by the nature of educational institutions. Availability of Federal funds for graduate programs in science has permitted universities to use other funds for disciplines with less support, such as the arts and humanities, and thus maintain balance in development of the institution.

On a lesser scale, the NIGMS training grants to bioscience departments have had similar effects. These funds, although restricted in their use for specific programs, do free other departmental funds for other uses. Students not supported by the grant benefit indirectly. The strengthening of the department through an increase in faculty size and the acquisition of

[9]National Academy of Sciences, *Summary Report 1967, Doctorate Recipients from United States Universities* (Washington: National Academy of Sciences, 1968).

FIGURE 2
Trends in graduate enrollment and production of research doctorates (PhD's) by broad academic field.



Source: U.S. Office of Education, Enrollment for Advanced Degrees (publication series OE-54019).

National Research Council, Office of Scientific Personnel, Doctorate Records File.

equipment from grant funds benefits all persons in the department. This cannot have other than a desirable effect, but it does pose obstacles to easy assessment of the training grant programs.

Undergraduate Supply

Growth of graduate student enrollment and PhD production in a field depends obviously upon the availability of potential graduate students in undergraduate programs. If one goal of the NIGMS training grant program is to increase the number of doctorates in the biosciences, there must be an adequate number of able undergraduates capable of undertaking graduate work. To determine if this pool of students is available, it is important to know both the number and quality of bioscience baccalaureates who might enter graduate work.

Bioscience graduate students are not as homogeneous in baccalaureate background as those in other natural sciences, and few studies report ability measures of bioscience baccalaureates. Slightly more than 60 percent of the bioscience PhD's were bioscience majors as undergraduates. In contrast, 75 percent of the physics PhD's and 85 percent of the chemistry PhD's were physics and chemistry majors, respectively, as undergraduates.[10] The data in Table 4 indicate relative sizes of the baccalaureate

[10] *Doctorate Recipients from United States Universities, 1958-1966* (Washington: National Academy of Sciences, 1967), pp. 45 and 252.

TABLE 4

Bioscience Degrees Awarded, Fiscal Years 1961-1967[a]

Fiscal Year	Bioscience Baccalaureates		Bioscience Master's Degrees		Bioscience Research Doctorates	
	Number	% All Bacc.	Number	% All Master's	Number	% All PhD's
1961	27,579	8	4,004	5	1,344	13
1962	28,375	7	4,293	5	1,506	13
1963	31,092	8	4,945	5	1,611	13
1964	34,398	7	5,596	6	1,846	13
1965	36,888	8	6,134	5	2,103	13
1966	42,064	8	7,102	5	2,297	13
1967	44,991	8	8,420	5	2,515	12

[a]*Bioscience includes all biological and health science specialties but excludes agriculture and forestry.*

Source: *U.S. Office of Education, Earned Degrees Conferred, Publication series OE-54012.*
National Research Council, Office of Scientific Personnel, Doctorate Records File.

bioscience pool and the doctorate output for the years 1961-1967. Chemistry majors also constitute a large source of graduate students in the biosciences.

The number of bioscience PhD's is about 9 percent of the number of baccalaureate degrees awarded 5 years earlier. For physics and chemistry this proportion is 15 to 20 percent. Therefore, if the quality of the bioscience baccalaureate group is good, an adequate number of graduate students would be available for a substantial increase in PhD output. A recent study by the National Opinion Research Center (NORC) of June 1961 U.S. college graduates indicates that bioscience baccalaureates compare favorably in academic performance with those from other disciplines.[11] In the study academic performance was measured by a weighted grade point average called the "academic performance index." The weightings were designed to equate grades in different subjects within institutions. The results are given in Table 5.

Between 13 percent and 26 percent of the bioscience baccalaureates ranked in the top 20 percent of all graduates based on the academic performance index, and between 58.9 percent and 56.6 percent were above the 50th percentile. By this measure the bioscience group has proportionately as many able students as most other fields. Therefore, an increase in the number of graduate students in the biomedical sciences is possible without sacrificing quality.

A summary of data available from the U.S. Office of Education concerning growth of undergraduate and graduate enrollments and degrees for the past decade shows the following pattern of increases during the period indicated:

		Biosciences (excluding health & agr.)	All Fields
College freshmen	1958-1968	NA	+93%
Baccalaureates	1958-1967	+101%	+66
1st year grad. students	1961-1968	+113	+117
Master's degrees	1958-1967	+163	+141
Research doctorates	1958-1968	+136	+159

These data show that the biosciences have been growing much faster than the total of all fields at the undergraduate level; they have kept pace

[11] James A. Davis, *Great Aspirations: Volume One, Career Decisions and Educational Plans During College*, National Opinion Research Center (University of Chicago, March 1963).

TABLE 5

Percentage of June 1961 Bachelors by Undergraduate Major and Academic Performance Index[a]

Undergraduate Major	Total Number (1000's)	Percentage of Bachelors Grouped by Academic Performance Index (in percentiles)		
		1st–20th Percentile	21st–49th Percentile	50th and lower Percentile
BIOLOGY	1,318	19.0	39.9	41.0
BIOLOGICAL SCIENCES[b]	738	26.0	30.6	43.3
PreMEDICAL	487	32.2	49.0	18.6
OTHER HEALTH	1,753	18.1	42.4	39.3
AGRICULTURE	734	8.9	28.8	62.1
CHEMISTRY	1,482	27.7	36.1	36.1
PHYSICS	830	43.2	28.3	28.4
MATHEMATICS	1,298	31.1	33.5	35.2
OTHER PHYSICAL SCIENCES	867	18.2	38.3	43.4
ENGINEERING	4,967	19.7	34.6	45.6
PSYCHOLOGY	1,336	25.3	37.2	37.4
OTHER SOCIAL SCIENCES	4,334	21.6	38.9	39.4
HUMANITIES	8,560	30.4	38.5	31.0
EDUCATION	14,393	12.7	39.8	47.4
BUSINESS	7,038	8.5	30.1	61.3
OTHER PROFESSIONS	2,081	14.7	33.9	51.2
NOT ELSEWHERE CLASSIFIED	679	13.1	25.4	61.4

[a] *Percentages may not sum to 100 because of rounding.*

[b] *Anatomy, biochemistry, botany, biophysics, entomology, genetics, microbiology, pathology, pharmacology, physiology, zoology, and other biological sciences.*

Source: Davis, J. A., Great Aspirations: Volume One, *p. 538.*

with the total in the first-year graduate enrollments and master's degrees; but they lag in the production of research doctorates. This lag, at the doctoral level, is not only of concern in terms of research, but it restricts the number of well-qualified staff available to teach the rapidly expanding undergraduate classes in the biosciences.

Types of Support

Training grants constitute only one type of support for graduate education. There are, in addition to personal sources of income, at least four types of support for education and training beyond the first degree. These are: training grants, national fellowships, research grants (which lead to employment of graduate students as research assistants), and university fellowships or assistantships. Each of these provides a different kind and form of support. In evaluating the NIGMS training grant program, its impact on the quantity and quality of personnel available for research in the biomedical sciences, and the capabilities of educational institutions to provide these educational opportunities, some comparisons must be made among the possible methods of support.

Training grants are oriented primarily toward research training. They permit the departments great flexibility and responsibility for the design and operation of their programs. Trainees, typically first-year graduate students, are selected by the local program director. Cooperative efforts of a group or all the faculty in a department are a necessary

prerequisite for a grant. In some cases, interdisciplinary cooperation is involved. Training grants provide funds for the development of faculty and facilities as well as stipends for students. Opportunities to improve weak aspects of graduate programs become apparent.

National and university fellowships and assistantships supply student stipends. Although there is no direct support for the development of the department or area in which training is provided, the cost-of-education allowance does supply funds that can be used for such purposes. The national fellowships that are awarded on the basis of academic ability usually have no limitations on the area of study, except for the broad field. National fellowship holders usually seek training in strong departments and thus make little contribution to improving the quality of the graduate student group in less-distinguished departments. Bioscience fellows are typically in their second or third year of graduate work and are generally a more select group that the first-year trainees.

Research grants are directed toward the solution of specific problems and thus are only secondarily related to education and training. They are usually administered by a single faculty member and are not generally concerned with the over-all strength of education and training in the department. The allocation of faculty support and funds for supplies and equipment is determined, quite properly, by the requirements of the problem. Students may receive support from research grants, but their status is more that of an employee than a trainee.

Graduate student support occurs in different mixtures among universities and among disciplines within a university. The mixture of support affects the quality and productivity of training programs for the PhD, since it is clear that graduate education is intimately related to other activities and resources of a department. There must be an adequate level of research to attract and retain a competent faculty. Facilities and equipment must be appropriate to the needs of the discipline. This has been recognized by NIGMS in its selection of methods used to assess the potential of a department to carry out the purpose of the training grant program.

To give some further perspective of the NIGMS training grant contribution to graduate education in the biosciences, it is of interest to make comparisons of NIGMS expenditures with certain total higher education budgets. In fiscal year 1967, NIGMS spent $63 million on training grant and fellowship programs. This was 47 percent of its total appropriation for that year, but it represented only 6 percent of the total NIH annual budget[12] and only 0.7 percent of the $9.6 billion "education and general" expenditures of higher education for fiscal year 1966.[13] There are no reliable estimates available that would indicate what portion of the $9.6 billion was used for bioscience graduate education, so it is not possible to say what fraction of all bioscience graduate education was supported by the $63 million in NIGMS grants. However, it is possible to provide rough estimates of the percentage of all bioscience graduate students supported by NIGMS and the proportion of their total expenses derived from NIGMS funds.

Data from this study show that in fiscal year 1965 NIGMS supported 5,200 pre-PhD trainees and fellows, and provided $13,368,000 in stipend and dependency allowances. A study of graduate student finances conducted by the U.S. Office of Education[14] indicated that there was a total of 17,550 bioscience graduate students in fiscal year 1965. These students received a grand total of $50,502,000 in stipend and dependency grants from all sources, and their *total* income (stipend, earnings, borrowing, etc.) was $82,450,000.

[12]National Institutes of Health, *Basic Data* (National Institutes of Health, 1968).

[13]American Council on Education, *A Fact Book on Higher Education*, 2d Issue, (Washington: American Council on Education, 1968).

[14]U.S. Department of Health, Education, and Welfare, *Survey of Academic and Financial Status of Graduate Students, Spring 1965*.

Therefore, NIGMS supported about 30 percent of the bioscience graduate students and contributed about 26 percent of their stipend support and 16 percent of their total income.

SUMMARY

- The Graduate Research Training Grant Program of the National Institute of General Medical Sciences (NIGMS) provides support for graduate student stipends and tuition and for strengthening the departments in which graduate training is given. Bioscientists with graduate research training of this kind are needed by society to:

  continue the contributions of research in providing a rational basis for the maintenance of health;

  provide staff for medical school departments to increase physician manpower to meet rising expectations for the delivery of health care; and

  provide faculty for the expanding bioscience enrollments of colleges and universities.

- In providing authority for support of research training, the Congress recognized the importance of an adequate number of biomedical scientists to meet the nation's needs. In 1958 the Division of General Medical Sciences was formed within the National Institute of Health, and in 1962 the division was raised to "institute" status as the National Institute of General Medical Sciences. The NIGMS was to "conduct and support research training in the general and basic medical sciences and related natural or behavioral sciences." The Research Training Branch was to strengthen research institutions and assist in the research training of competent graduate students.

- In 1965, 30 percent of the pre-PhD bioscience graduate students received NIGMS training and fellowship grants. These grants accounted for approximately 26 percent of all stipend support and 16 percent of the total income for these students during 1965.

- Projection of future manpower requirements is dependent on the nature of the assumptions made about key variables. Unassailable quantitative projections of future need for bioscientists do not exist, but the qualitative assessments of national committees and the quantitative studies that are available all indicate a need for more research doctorates in the biosciences during the coming decade than are now being produced. The existing quantitative studies show the projected supply of doctorate-holding bioscientists to be about half the projected demand.

- The number and the quality of students in the undergraduate bioscience "pipeline" seem adequate to support a marked increase in the percentage continuing to the PhD without lowering quality.

- The recent rapid growth of bioscience enrollments at the undergraduate level, coupled with the less-than-average growth at the doctorate level, indicates a less-than-adequate number of well-qualified college and university staff available to teach the expanding undergraduate classes.

- NIGMS support for graduate training in the biomedical sciences through traineeship and fellowship programs varies by academic field. The amount of stipend and dependency support, the percentage of doctorate-granting departments having NIGMS trainees, and the median total months of support supplied to students all reveal a great deal of variation among the different bioscience fields.

- Efficient support for a graduate bioscience department requires a balanced distribution among training grants, research grants, and facilities grants.

CHAPTER II

SCOPE OF THE STUDY

SCOPE OF THE STUDY
DATA SOURCES
DEFINITIONS

SCOPE OF THE STUDY

In a letter of September 1, 1965 to Dr. Frederick Seitz, President of the National Academy of Sciences, Dr. Frederick L. Stone, Director of the National Institute of General Medical Sciences, requested assistance from the Academy in conducting an "evaluative study" of the extensive NIGMS training grant program. Specifically, the study was to concern itself with such questions as:

> What have been the patterns of NIGMS training grant support to bioscience departments?
>
> What impacts have the NIGMS grants had upon the departments? Has PhD production been increased? What changes were brought about in faculty strength, physical facilities, and curricula?
>
> What have been the training support patterns for NIGMS trainees and fellows? How many students have been supported in each bioscience field? For how long? At what point in their graduate careers? How much support did they receive?
>
> What percentage of the NIGMS pre-PhD trainees and fellows ultimately attain the PhD? How does the PhD attainment rate for the NIGMS trainees and fellows compare with that of other graduate students? Is the PhD attainment rate affected by patterns of NIGMS support?
>
> What is the baccalaureate-to-doctorate time lapse of NIGMS trainees and fellows? How does it compare with the time lapse of doctorate recipients in the same fields without NIGMS support?
>
> What are the post-training careers of NIGMS trainees and fellows? For what types of employers do they work? What are their major work activities? How productive are they in biomedical research?

Although the descriptive statistics presented in Chapter III and IV provide answers to these questions and are essential to the study, they are not sufficient. The request from NIGMS was for an *evaluative study* and called for interpretation and weighing of the outcomes of the program: Which policies were successful? Which were not? What recommendations for future action would be appropriate? These evaluations have been made by an Advisory Committee of biomedical scientists, whose names are listed

in the Preface to this report. The committee had the assistance of staff members of the Office of Scientific Personnel (OSP) of the National Research Council who gathered and tabulated the basic descriptive data. These data were reviewed and interpreted by the members of the Advisory Committee, who were also responsible for the recommendations made in this report.

DATA SOURCES

The most important sources used by the OSP staff in assembling the basic statistical data for the report were the following:

1. NIGMS records of trainees, derived from the "Statement of Appointment of Trainee" forms submitted to NIGMS by training program directors in bioscience departments. These forms contain identifying information (birth date, sex, citizenship, marital status), academic degrees held, degree sought, field of training, and months and dollars of support expected to be received during the fiscal year.

2. NIGMS records of fellows derived from Fellowship Award Statements. These forms contain much the same information as the trainee records. Months and dollars of support reported are actual, not estimated, figures.

3. The OSP Doctorate Records File, a register of all earned research doctorates from U.S. universities since 1920. The Doctorate Records File contains identifying information, a complete listing of all educational institutions attended and degrees attained, along with major fields of degrees, sources of support in graduate school, and postdoctoral employment plans. The file is compiled from the Survey of Earned Doctorates conducted annually by the OSP with the cooperation of the Graduate Deans. Research doctorates in all fields are recorded, but professional degrees such as the MD, DDS, and DVM are not included.

4. A follow-up survey conducted in 1968 of all pre-PhD trainees who had received NIGMS support at any time during the period 1958-1962. Each former trainee was asked to supply information about his post-training employment experiences, including types of employers and principal work activities.

5. The National Register of Scientific and Technical Personnel maintained by the National Science Foundation. The Register circulates a survey questionnaire every two years to collect information that describes the employment characteristics of scientists. These data were used to supplement those from the follow-up survey of pre-PhD trainees (number 4 above).

6. Data from the Institute for Scientific Information "Source Index" and "Science Citation Index." These data were used to show the number of publications and number of citations per year for each NIGMS trainee who received a PhD. Publication and citation rates were compared with those for PhD's in matched fields who had not received NIGMS support.

7. The Report of Expenditure forms submitted by program directors to NIGMS. These forms show the actual expenditures during the fiscal year for stipends, dependency allowance, professional and other staff salaries, equipment, travel, and supplies. Since the data were not on cards or tapes, they had to be collected by means of a time-consuming, hand-coding process. Therefore, only data for odd-numbered grants in four training fields were collected.

8. The U.S. Office of Education (USOE) data on enrollment and degrees. Each year, the USOE publishes books showing the numbers of degrees granted by each college and university (*Earned Degrees Conferred* series) and the number of graduate students enrolled (*Enrollment for Advanced Degrees* series). These data are listed by institution within academic major.

The sources listed as 1, 2, and 3 (traineeship records, fellowship records, and Doctorate Records File) were merged and matched by name to provide a master record showing the academic history, NIGMS-support history, and doctoral attainment record of each trainee and fellow. This master file provided information about individuals, training fields, training institutions, and departments.

Sources 4, 5, and 6 (follow-up survey of trainees, National Register, and Institute for Scientific Information) supplied information about the post-training activities of NIGMS-supported persons. They described the type of employer, major work activity, and research publication record of former trainees.

Data from sources 7 and 8 (Report of Expenditure forms and USGE surveys), supplemented by tabulations from the master file, provided information about changes that occurred in departments that received training grants and in departments that did not.

DEFINITIONS

Tabulations from the data sources listed above appear in Chapters III and IV. Every effort has been made to make the table titles and column headings as complete and self-explanatory as possible, and the text comments on any unusual terms used. However, since most of the tables contain one or more of the following nine terms, it is especially important that the reader understand clearly the definitions of these terms before studying the tabulations.

Trainee: Any person who had received support from the NIGMS Graduate Research Training Grant Program for one or more months.

Fellow: Any person who had received an NIGMS fellowship award for one or more months.

Trainee-Fellow: Any person who had been both an NIGMS trainee and NIGMS fellow.

Fiscal Year (FY): The interval from July 1 through June 30. It approximates the academic year. For example, fiscal year 1958 is July 1, 1957 through June 30, 1958, and is approximately the same as academic year 1957-1958. In general, the fiscal year is that in which the student was in training as opposed to the fiscal year of funding. Funds are normally appropriated and committed one year ahead of the year of expenditure.

Characteristics: Age, citizenship, sex, and marital status. Although certain of these are variable, the characteristics of the person were regarded as remaining fixed and were defined by his earliest NIGMS training record.

Field of Training: The major field of research training for the trainee or fellow. Although this field could change in the case of a person receiving more than one period of support, the field was considered fixed and was defined by the earliest training record. Most of the tabulations specify 14 training fields plus "All other" and "Unknown." The subfield components of each of these major fields are listed in Appendix B of this report.

Academic Level: The person's level of formal education relative to the professional doctorate or research doctorate degree as indicated on the "Statement of Appointment of Trainee" form or on the fellowship application form. The level was defined by the earliest NIGMS record and was regarded as fixed for the entire period of training. Five academic levels were specified:

Pre-PhD—a person who indicated he was seeking a PhD (or other *research* doctorate, such as D.Sc.) or a master's degree.

Pre-MD—a person seeking an MD or other *professional* doctorate, such as DDS, DVM, etc.

Post-MD — any person who had attained a professional doctorate prior to receiving his first NIGMS support.

Post-PhD — any person who had attained a research doctorate prior to receiving his first NIGMS support. A person who had attained both a professional and a research doctorate was classified as post-PhD.

Other—includes students not candidates for a degree, pre-nursing students, and those of unknown academic level.

Baccalaureate-to-PhD time lapse: Two kinds of time lapse are reported: "Total Time" refers to the *total calendar time* between baccalaureate and doctorate; "Registered Time" is the *total time registered in a university*, full- and part-time, between baccalaureate and PhD.

Median: The value below which 50 percent of the cases fall. For instance, a median time lapse of 5.5 years would indicate that half of the persons attained the doctorate in 5.5 years or less, and half required more than 5.5 years.

The statistics resulting from the analysis of these data are useful, but they contain some unavoidable inaccuracies. Some coding errors escaped the checking procedure; some inaccurate matches resulted as data from different sources were merged on the basis of trainee name, birth date, etc; classification schemes for items such as academic specialties differ from one data source to another; and some important items of information simply were not available. Nevertheless, the over-all quality of the statistics in this report is judged to be good. Data of poor quality have been eliminated. Wherever possible, the consistency of data has been checked by comparison of information obtained from independent sources. In general, agreement was within $\pm$ 5-10 percent. The more recent data are more accurate.

The Advisory Committee reviewed a large amount of preliminary data in computer-tabulated form, called attention to gaps in information, selected tables that were the most critical for each section of the report, and wrote draft copy of the report, interpreting and integrating the basic data. The committee formulated the evaluations and recommendations.

The committee's task of interpretation and evaluation was complicated by the rapid changes in graduate education during the period under study (1958-1967). The many forces operating on educational institutions made it very difficult to determine the specific effects of the NIGMS training program. Every effort has been made in this report to call attention to those factors that may have contributed to observed differences between NIGMS-supported and non-NIGMS-supported groups.

In spite of these difficulties, the study provides important information on the NIGMS training program and its impact on 30,000 students, on their careers, and on the training departments in which they were trained.

CHAPTER III

TRAINING GRANT SUPPORT AND IMPACT: BIOSCIENCE DEPARTMENTS

PATTERNS OF NIGMS SUPPORT TO BIOSCIENCE DEPARTMENTS

Support by Field
Support by Geographic Region
Support by Type of Institutional Control

IMPACT OF SUPPORT ON BIOSCIENCE DEPARTMENTS

PhD Production
Graduate Enrollments
Faculty and Scientific Environment
Physical Facilities
New Fields of Biomedical Science
Clinical Research Training

SUMMARY

PATTERNS OF NIGMS SUPPORT TO BIOSCIENCE DEPARTMENTS

NIGMS support for graduate training in the biomedical sciences through traineeship programs and fellowship programs varies by academic field. The amount of stipend and dependency support, the percentage of doctorate-granting departments having NIGMS trainees, and the median total months of support supplied to students all reveal a great deal of variation among the different bioscience fields.

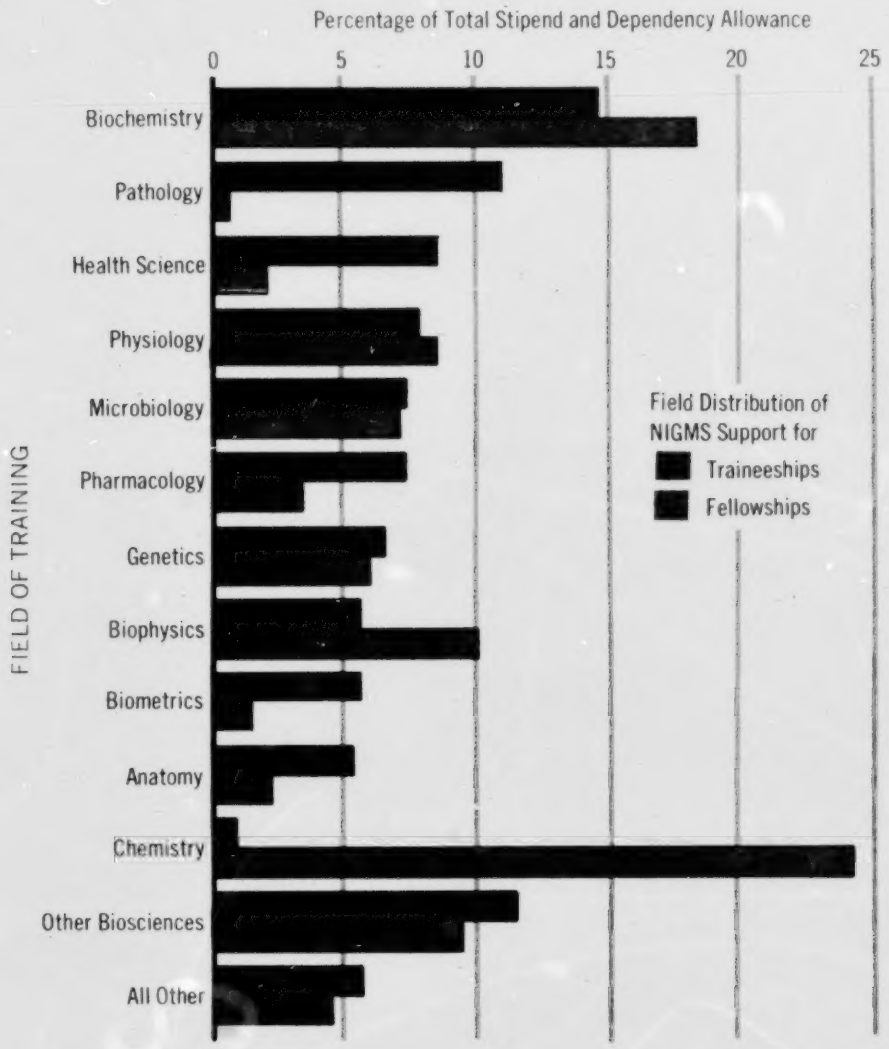
Support by Field

The distribution of stipend and dependency funds among the biomedical fields in fiscal year 1966-1967 is shown in Figure 3. Biochemistry, physiology, and microbiology ranked high in both traineeship and fellowship programs. Chemistry and biophysics were leading fields for fellowship support, but were not supported appreciably by traineeships. The converse was true for pathology.

The percentage of departments within a given bioscience field having NIGMS trainees varied from a high of 87 percent for biometrics[15] to a low of

[15]Biometry was early identified as a field of critical shortage but one that could not be supported within a "categorical" institute of the NIH. In 1953, well before the establishment of the NIGMS, the National Advisory Health Council adopted a resolution recommending that the Public Health Service aid institutes to undertake programs for training biometricians for research careers (see Appendix A, page 80 for details).

FIGURE 3
Percentage distribution of NIGMS traineeship and fellowship support for stipend and dependency allowances, by training fields, fiscal years 1966 and 1967 combined.



Source: NIGMS, Statement of Appointment of Trainee and Fellowship Award Statement.

45 percent for genetics. Four hundred of the 761 departments that granted PhD's in the nine fields listed in Table 6 received NIGMS training grants at some time during the period fiscal years 1958-1967, and all of the departments that were large producers of PhD's in the period 1953-1957 received some training grant support during fiscal years 1958-1967. The 400 NIGMS-supported departments accounted for 7,018 of the research doctorates awarded in the nine fields between fiscal years 1958 and 1967, or 73 percent of the total, whereas the 361 departments in the nine fields without NIGMS support awarded 2,533 research doctorates, or 27 percent of the total.

TABLE 6

Number of Departments Granting Research Doctorates in Nine Bioscience Fields, Departments with NIGMS Training Grants versus Departments without NIGMS Training Grants, Fiscal Years 1958-1967

Field of Training	Total Number of Departments (100%)	Total Number of PhD's Awarded (100%)	With NIGMS Trainees				Without NIGMS Trainees			
			Depts.		PhD's Awarded		Depts.		PhD's Awarded	
			No.	%	No.	%	No.	%	No.	%
BIOCHEMISTRY	132	3,286	66	50	2,506	76	66	50	780	24
PATHOLOGY	48	255	32	66	198	78	16	33	57	22
PHYSIOLOGY	123	1,019	59	48	665	65	64	52	354	35
MICROBIOLOGY	121	2,225	57	47	1,711	77	64	53	514	23
PHARMACOLOGY	84	736	54	64	535	73	30	36	201	27
BIOMETRICS	23	140	20	87	136	97	3	13	4	3
ANATOMY	83	538	40	48	342	64	43	52	196	36
BIOPHYSICS	60	427	32	53	337	79	28	47	90	21
GENETICS	88	925	40	45	588	64	48	55	337	36

Source: *NIGMS, Statement of Appointment of Trainee. National Research Council, Office of Scientific Personnel, Doctorate Records File.*

TABLE 7

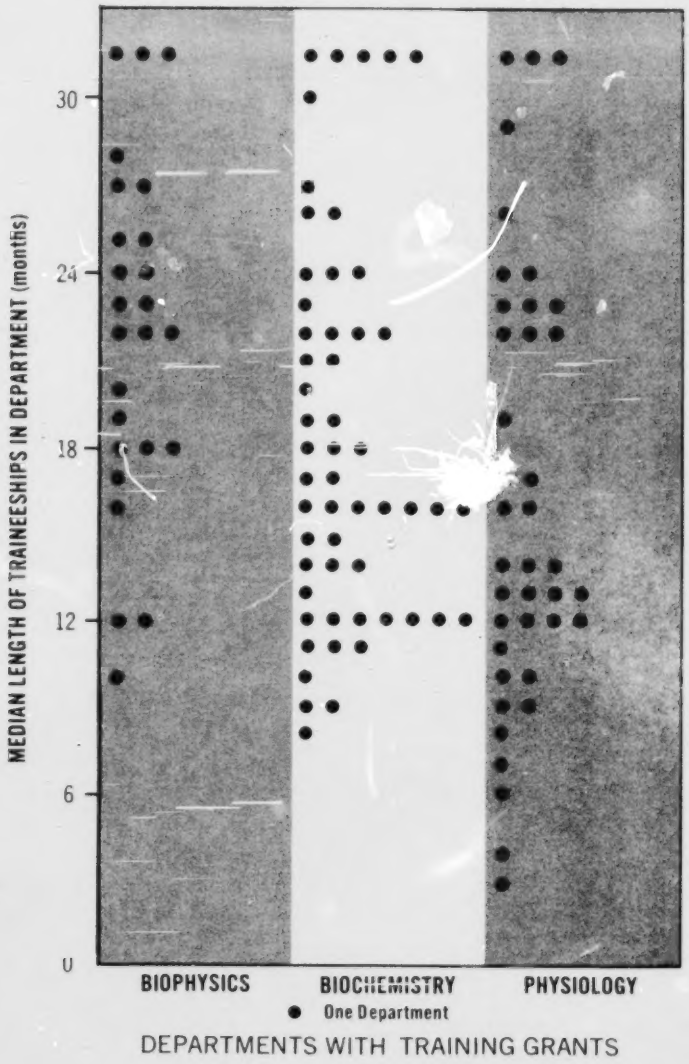
Total Months of NIGMS Support Received by Pre-PhD Trainees and Fellows Having First Award in Fiscal Year 1965, by Field of Training

Field of Training	NIGMS Support of Pre-PhD Trainees (in Months)[a]			NIGMS Support of Pre-PhD Fellows (in Months)[a]		
	Q1	Q2	Q3	Q1	Q2	Q3
TOTAL All Fields	**10.5**	**19.4**	**29.6**	**12.8**	**23.2**	**24.6**
BIOCHEMISTRY	10.7	17.2	27.4	22.1	23.4	24.7
PATHOLOGY	3.5	10.9	26.3	---	---	---
PHYSIOLOGY	10.2	18.6	29.0	11.9	22.6	24.2
MICROBIOLOGY	10.2	18.1	30.5	11.8	22.6	24.6
PHARMACOLOGY	11.8	24.8	34.8	22.2	23.5	24.9
BIOMETRICS	15.0	22.3	29.6	---	---	---
ANATOMY	11.1	22.6	32.3	11.8	22.6	24.5
BIOPHYSICS	12.0	22.3	31.2	12.5	23.0	24.4
GENETICS	11.6	23.0	31.8	17.5	23.1	24.2
OTHER BIOSCIENCES	5.3	15.6	24.6	12.4	23.0	24.3
CHEMISTRY	---	---	---	22.2	23.5	24.8
PHYSICAL SCIENCES & ENGINEERING (EXCLUDING CHEMISTRY)	19.0	27.0	32.0	22.2	23.3	24.4
HEALTH SCIENCES	11.9	23.0	31.4		---	---
MEDICAL STUDENT RESEARCH TRAINING	---	---	---	---	---	---
ALL OTHER	9.1	12.6	24.8	---	---	---
UNKNOWN	---	---	---	---	---	---

[a] *Q1 – first quartile: one fourth of the students received the number of months of support indicated, or less, Q2 – second quartile or median: one half received the number of months of support indicated, or less; Q3 – third quartile: three fourths received the number of months of support indicated, or less.*

Source: *NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.*

FIGURE 4
Median lengths of NIGMS traineeships at departments with training grants in biophysics, biochemistry, or physiology, fiscal years 1958-1965 combined.

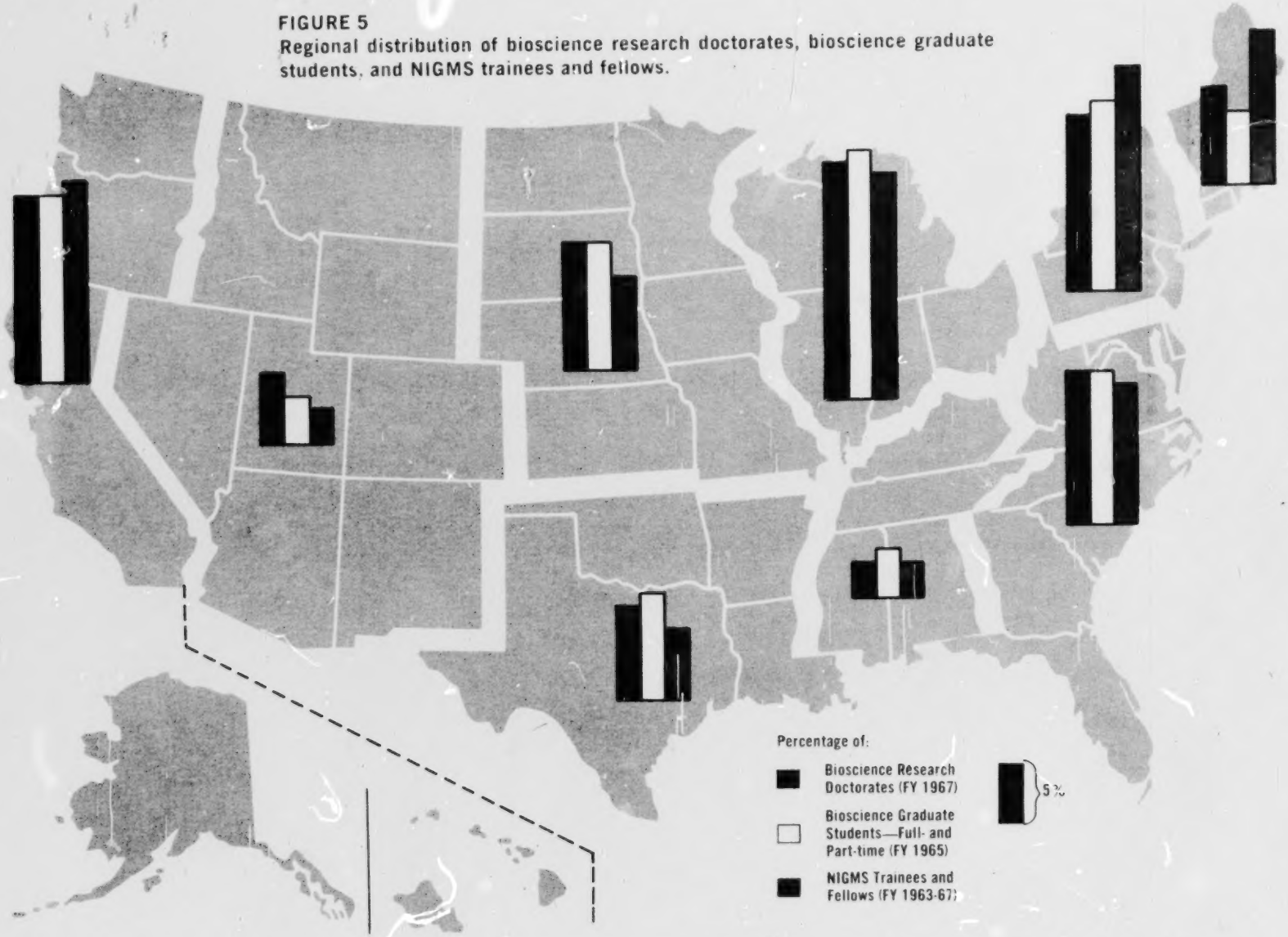


Note: Only departments with ten or more NIGMS trainees have been included.
Source: NIGMS, Statement of Appointment of Trainee.
National Research Council, Office of Scientific Personnel, Doctorate Records File.

Table 7 shows the median total months of NIGMS traineeship support provided to bioscience graduate students. The period of support for students who received their first traineeships in fiscal year 1965 ranged from a median of 24.8 months for pharmacology to 10.9 months for pathology pre-PhD's. The total months of support provided by NIGMS fellowships, however, revealed much less variation, with a median for each field falling between 22 and 23 months.

Traineeship patterns in graduate departments within a given bioscience field differ widely. Figure 4 and Table 8 illustrate these differences. Of

FIGURE 5
Regional distribution of bioscience research doctorates, bioscience graduate students, and NIGMS trainees and fellows.


Percentage of:
Bioscience Research Doctorates (FY 1967)
Bioscience Graduate Students—Full- and Part-time (FY 1965)
NIGMS Trainees and Fellows (FY 1963-67)
5%

Source: National Research Council, Office of Scientific Personnel, Doctorate Records File. United States Office of Education, Enrollment for Advanced Degrees, Fall 1964. NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.

TABLE 8

Number of Departments, by Median Length of NIGMS Traineeship in Department, Fiscal Years 1958-1965[a]

Field of Training	Total Number of Departments	Number of Departments by Median Length of NIGMS Traineeships				
		1–6 Months	7–12 Months	13–18 Months	19–24 Months	25 or more Months
BIOCHEMISTRY	54	—	14	18	13	9
PATHOLOGY	50	13	15	10	5	7
PHYSIOLOGY	39	3	11	11	9	5
BIOPHYSICS	25	—	3	5	9	8
MICROBIOLOGY	41	1	11	16	9	4
PHARMACOLOGY	40	5	4	8	13	10
BIOMETRICS	24	7	4	3	4	6
ANATOMY	30	3	9	8	6	4
GENETICS	23	1	2	9	10	1

[a]*Only departments with 10 or more NIGMS trainees have been included.*

Source: *NIGMS, Statement of Appointment of Trainee.*
National Research Council, Office of Scientific Personnel, Doctorate Records File.

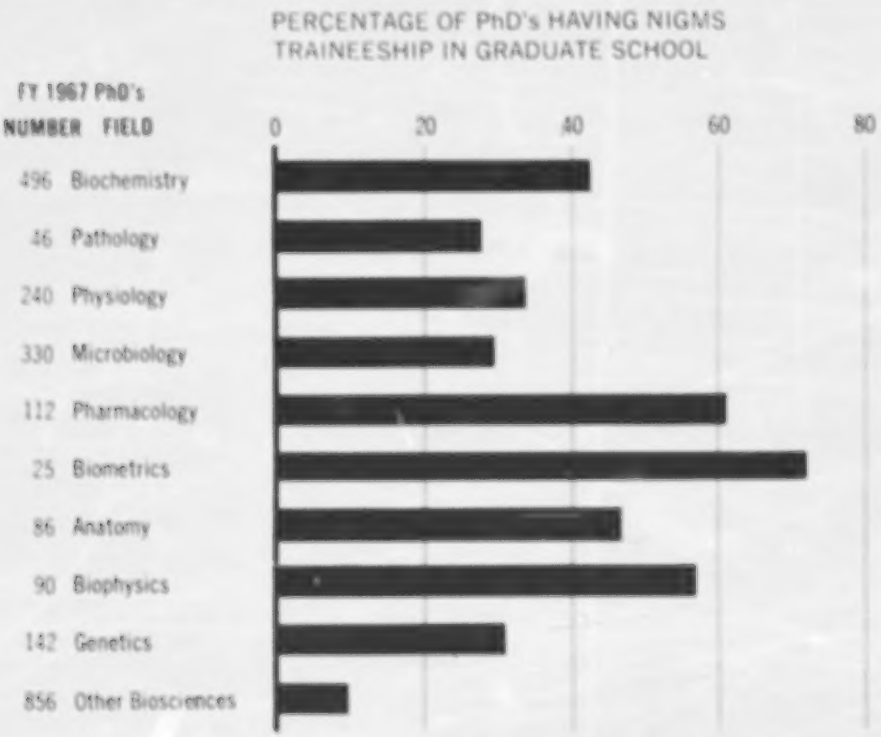
TABLE 9

Geographic Distribution of Bioscience Research Doctorates, Bioscience Graduate Students, NIGMS Traineeships and Fellowships, and Federal Academic Science Support

Region	Bioscience PhD's Awarded in FY 1967	Bioscience Graduate Students FY 1965 (full- and part-time)	NIGMS Trainees and Fellows FY 1963–1967	Federal Academic Science Support FY 1966	
	Percent	Percent	Percent	Dollars in Thousands	Percent
TOTAL	100	100	100	2,158,291	100
NEW ENGLAND	8	6	13	232,857	11
MIDDLE ATLANTIC	15	16	19	406,387	19
EAST NORTH CENTRAL	20	21	19	409,945	19
WEST NORTH CENTRAL	11	12	8	158,768	7
SOUTH ATLANTIC	13	13	12	260,716	12
EAST SOUTH CENTRAL	3	4	3	85,946	4
WEST SOUTH CENTRAL	8	9	6	146,520	7
MOUNTAIN	6	4	3	101,507	5
PACIFIC	16	16	17	355,645	16

Source: *NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.*
National Science Foundation, Federal Support to Universities & Colleges FY 1963–1966 (NSF 67-14).
U.S. Office of Education, Enrollment for Advanced Degrees, Fall 1964.
National Research Council, Office of Scientific Personnel, Doctorate Records File.

FIGURE 6
Percentage of fiscal year 1967 bioscience research doctorates who had received an NIGMS traineeship in graduate school.



Source: NIGMS, Statement of Appointment of Trainee.
National Research Council, Office of Scientific Personnel, Doctorate Records File.

the 54 biochemistry departments having ten or more NIGMS trainees during the period fiscal year 1958-1965,[18] 14 departments provided a median length of support for trainees of 12 or fewer months; 31 for 13-24 months; and the remaining 9 for a median 25 or more months. Departments in the other bioscience fields reveal a similar variation.

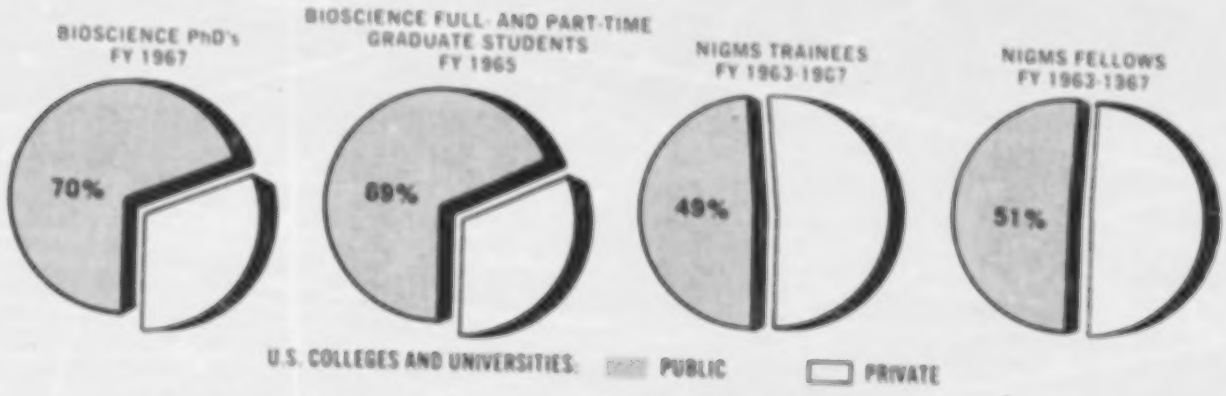
Support by Geographic Region

Regional distributions of NIGMS traineeship and fellowship funds are shown in Figure 5 and Table 9 with comparisons between NIGMS support and certain other indices of academic productivity. The New England and Middle Atlantic areas received about 32 percent of NIGMS support and 30 percent of total Federal academic science support. They enrolled 22 percent of the bioscience graduate students and produced 23 percent of the bioscience PhD's. The West North Central, West South Central, and Mountain regions, combined, received 17 percent of the NIGMS support and 19 percent of the Federal academic science support; yet they enrolled 25

[18]Trainees having their first appointment in fiscal years 1966 and 1967 have been omitted from Table 7. These trainees could have obtained a maximum of only 12 or 24 months support through fiscal year 1967, and many have and will continue to receive support in fiscal years 1968 and 1969. The calculated median total months of support is more representative if these cases are excluded.

FIGURE 7

Distribution between public and private universities of bioscience research doctorates, bioscience graduate students, and NIGMS trainees and fellows.



Source: National Research Council, Office of Scientific Personnel, Doctorate Records File.
United States Office of Education, Enrollment for Advanced Degrees, Fall 1964.
NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.

percent of the bioscience graduate students and produced 25 percent of the bioscience PhD's. Support for the other four geographic regions was more closely related to PhD production and graduate student enrollment.

Detailed state-by-state data are presented in Appendix C of this report. The appendix table includes data for each state showing the number of PhD-granting departments and the number of bioscience PhD's who received NIGMS support. For example, Illinois had 42 institutions with PhD-granting departments in one or more of the bioscience fields, and 28 of these departments received NIGMS support. Pennsylvania had 57 institutions with PhD-granting departments in one or more of the biosciences, 22 of which received NIGMS support. As a consequence, almost half (64 of 132) of the Illinois bioscience PhD's had NIGMS support, while only one third (33 of 103) of the bioscience PhD's from Pennsylvania were NIGMS-supported. In total, 29 percent of the bioscience PhD's of fiscal year 1967 had received NIGMS traineeship assistance. This percentage agrees very well with the estimate given in Chapter I that 30 percent of all bioscience pre-PhD's were on NIGMS training grants. Figure 6 shows the percentage of fiscal year 1967 PhD's in selected bioscience fields who were NIGMS trainees in graduate school.

Support by Type of Institutional Control

The distribution of NIGMS trainees by type of institutional control is given in Figure 7. Public institutions enrolled 69 percent of the bioscience PhD's, but only half of the NIGMS trainees and fellows were in public universities. This finding is consistent with the large percentage of NIGMS support to the New England and Middle Atlantic regions, where the majority of private universities are concentrated.

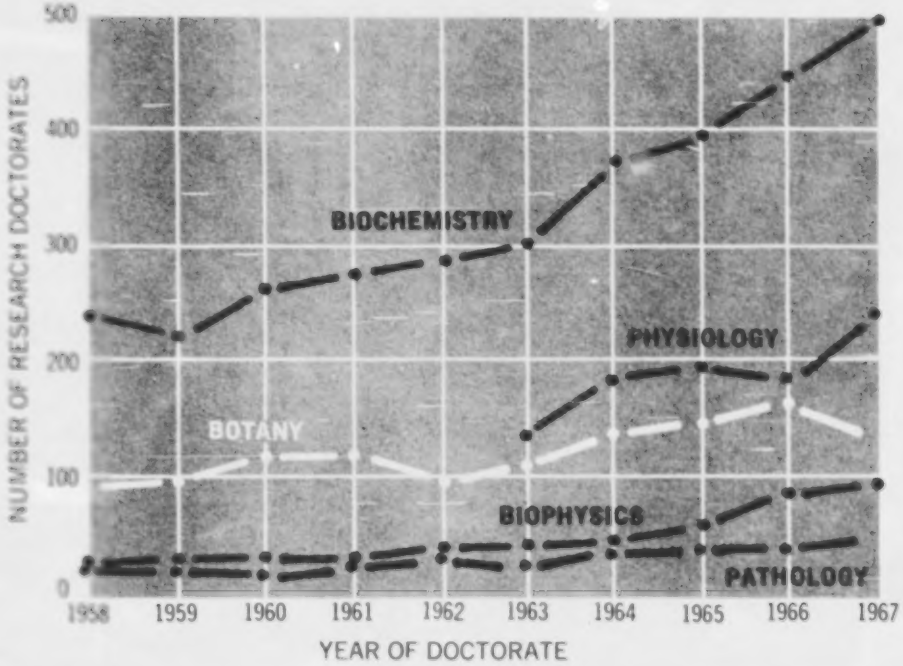
IMPACT OF SUPPORT ON BIOSCIENCE DEPARTMENTS

PhD Production

The impact of a training grant on the PhD production of a department is influenced both by the size and by the academic field of the department. In order to study the effect of the variation in fields in some detail, the committee selected four areas for special study: biochemistry as representative of a modestly growing field, physiology as a field showing relatively slow growth, biophysics as a rapidly growing new field, and pathology as a field lacking a

FIGURE 8
Doctorate production in five bioscience fields, fiscal years 1958-1967.

	PERCENTAGE FY 1958-1963	INCREMENT FY 1963-1967
BIOCHEMISTRY	26	65
BIOPHYSICS	71	150
PHYSIOLOGY, ANIMAL	*	76
PATHOLOGY	50	119
BOTANY	20	21



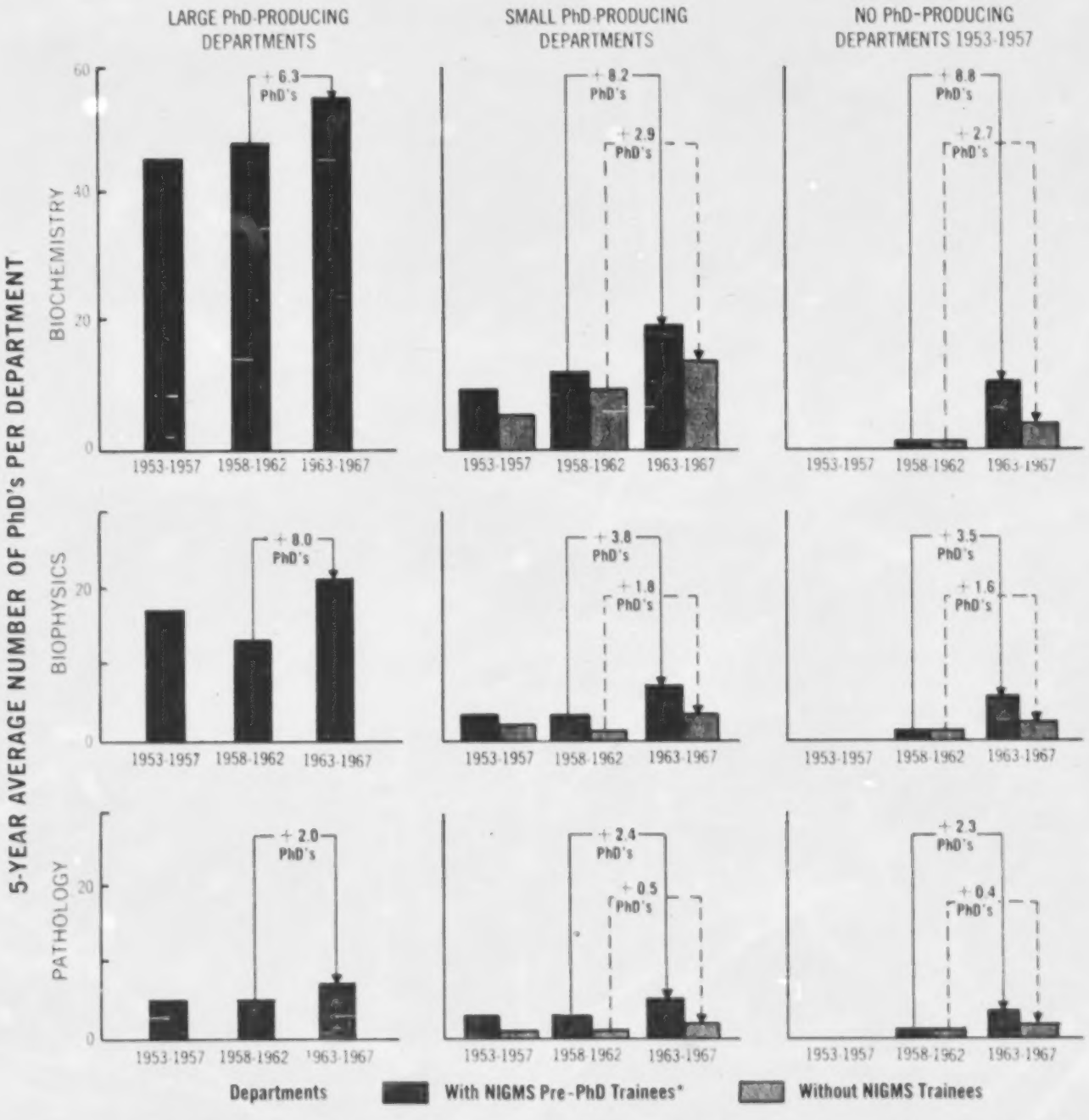
* Data for animal physiology is not available from the Doctorate Records File before FY 1963.
Source: National Research Council, Office of Scientific Personnel, Doctorate Records File.

tradition of research training. The growth of doctorate production in these four fields, along with botany as a comparison field unlikely to be affected by NIGMS support, is shown in Figure 8. The relatively sharp change in the rate of doctorate production after 1963 in the fields of biochemistry, physiology, and biophysics, but not botany, is suggestive of a positive effect of the training grants on these fields approximately five years after the start of the training grant program. It should be noted that most training in pathology has been at the postdoctoral level, and hence, cannot be completely measured by compilations of PhD production.

In order to study the effect of NIGMS training grants on departments of different size, the committee classified departments on the basis of doctorate production in a specific field during the period 1953-1957 as (a) large producers, (b) small producers, or (c) nonproducers of doctorates. This period was selected as a point of reference because it immediately preceded the start of the NIGMS training grant program. Figure 9 and Table 10 summarize the impact of training grants on PhD production of departments in three fields, equated for size of department. The upper section of Table 10 lists the data for biochemistry. The left-hand column shows the three departmental groups (large PhD-producers, small PhD-producers, and non-

FIGURE 9

Average number of research doctorates awarded per department in three 5-year periods, NIGMS supported versus nonsupported departments of biochemistry, biophysics, and pathology. (The groupings of departments differ for each field and are defined in Table 10.)



*"With Trainees" means department had one or more NIGMS pre-PhD trainees at anytime during the period 1958-1967.

Source: NIGMS, Statement of Appointment of Trainee.
National Research Council, Office of Scientific Personnel, Doctorate Records File.

TABLE 10

Trends in Production of Research Doctorates, NIGMS-Supported Versus Non-NIGMS-Supported Departments of Biochemistry, Pathology, and Biophysics, Fiscal Years 1953-1967

Classification of Department	Number of Departments	Number of Research Doctorates in 5-Year Periods						Increase in PhD Production from 1958-1962 to 1963-1967	
		1953-1957		1958-1962		1963-1967			
		Number of PhD's	5-Year Average per Department	Number of PhD's	5-Year Average per Department	Number of PhD's	5-Year Average per Department	Percent	5-Year Average per Department
BIOCHEMISTRY									
LARGE PhD-PRODUCING DEPARTMENTS (≥ 24 PhD'S 1953-1957)									
TOTAL All Departments	9	405	45.0	431	47.8	494	54.8	14.6	7.0
With NIGMS Pre-PhD Trainees: 1958-1967	8	381	47.6	398	49.7	449	56.1	12.8	6.4
With NIGMS Pre-PhD Trainees: 1963-1967 only	1	24	--	33	--	45	--	36.3	--
Without NIGMS Pre-PhD Trainees: 1958-1967	--	--	--	--	--	--	--	--	--
SMALL PhD-PRODUCING DEPARTMENTS (1-23 PhD'S 1953-1957)									
TOTAL All Departments	73	533	7.3	778	10.6	1,256	17.2	61.4	6.5
With NIGMS Pre-PhD Trainees: 1958-1967	29	258	9.0	371	12.8	615	21.2	65.8	8.4
With NIGMS Pre-PhD Trainees: 1963-1967 only	21	158	7.5	178	8.5	346	16.5	94.4	8.0
Without NIGMS Pre-PhD Trainees: 1958-1967	23	117	5.0	229	9.9	295	12.8	28.8	2.9
NO PhD-PRODUCING DEPARTMENTS FROM 1953 TO 1957									
TOTAL All Departments	46	--	--	64	1.4	248	5.4	287.5	4.0
With NIGMS Pre-PhD Trainees: 1958-1967	6	--	--	14	2.3	77	12.8	450.0	10.5
With NIGMS Pre-PhD Trainees: 1963-1967 only	4	--	--	1	--	26	--	--	--
Without NIGMS Pre-PhD Trainees: 1958-1967	36	--	--	49	1.4	145	4.0	195.9	2.7

BIOPHYSICS

LARGE PhD-PRODUCING DEPARTMENTS (≥ 7 PhD'S 1953-1957)									
TOTAL All Departments	5	83	16.6	66	13.2	106	21.2	60.6	8.0
With NIGMS Pre-PhD Trainees: 1958-1967	4	64	--	54	--	89	--	64.8	--
With NIGMS Pre-PhD Trainees: 1963-1967 only	1	19	--	12	--	17	--	--	--
Without NIGMS Pre-PhD Trainees: 1958-1967	--	--	--	--	--	--	--	--	--
SMALL PhD-PRODUCING DEPARTMENTS (1-6 PhD'S 1953-1957)									
TOTAL All Departments	20	43	2.2	43	2.2	101	5.1	134.0	2.9
With NIGMS Pre-PhD Trainees: 1958-1967	7	16	2.3	20	2.9	40	5.7	100.0	2.9
With NIGMS Pre-PhD Trainees: 1963-1967 only	4	9	--	15	--	37	--	146.7	--
Without NIGMS Pre-PhD Trainees: 1958-1967	9	18	2.0	8	0.8	24	2.7	200.0	1.8
NO PhD-PRODUCING DEPARTMENTS FROM 1953 TO 1957									
TOTAL All Departments	33	--	--	16	0.5	85	2.6	466.7	2.1
With NIGMS Pre-PhD Trainees: 1958-1967	6	--	--	3	0.5	26	4.3	766.7	3.8
With NIGMS Pre-PhD Trainees: 1963-1967 only	3	--	--	2	--	11	--	450.0	--
Without NIGMS Pre-PhD Trainees: 1958-1967	24	--	--	11	0.4	48	2.0	380.0	1.6

PATHOLOGY

LARGE PhD-PRODUCING DEPARTMENTS (≥ 5 PhD'S 1953-1957)									
TOTAL All Departments	3	16	--	15	--	21	--	40.0	--
With NIGMS Pre-PhD Trainees: 1958-1967	2	10	--	6	--	9	--	50.0	--
With NIGMS Pre-PhD Trainees: 1963-1967 only	1	6	--	9	--	12	--	--	--
Without NIGMS Pre-PhD Trainees: 1958-1967	--	--	--	--	--	--	--	--	--
SMALL PhD-PRODUCING DEPARTMENTS (1-4 PhD'S 1953-1957)									
TOTAL All Departments	22	40	1.8	36	1.6	67	3.0	86.1	1.4
With NIGMS Pre-PhD Trainees: 1958-1967	8	18	2.3	20	2.5	40	5.0	100.0	2.5
With NIGMS Pre-PhD Trainees: 1963-1967 only	3	6	--	4	--	10	--	150.0	--
Without NIGMS Pre-PhD Trainees: 1958-1967	11	16	1.5	12	1.1	17	1.5	41.0	0.5
NO PhD-PRODUCING DEPARTMENTS FROM 1953 TO 1957									
TOTAL All Departments	30	--	--	33	1.1	81	2.7	145.4	1.6
With NIGMS Pre-PhD Trainees: 1958-1967	12	--	--	14	1.2	44	3.7	214.3	2.5
With NIGMS Pre-PhD Trainees: 1963-1967 only	7	--	--	6	0.9	20	2.9	233.3	2.0
Without NIGMS Pre-PhD Trainees: 1958-1967	11	--	--	13	1.2	17	1.5	31.0	0.4

Source: National Research Council, Office of Scientific Personnel, Doctorate Records File.
NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.

PhD-producers), based on PhD output during 1953-1957. Each group is subdivided into those that (1) received NIGMS support during 1958-1962 and may also have been supported after 1962, (2) received NIGMS support during the period 1963-1967 but not during 1958-1962, and (3) received no NIGMS training grant support. Since it requires five years for a program to begin to produce PhD's, few persons supported after 1963 would have attained the degree by 1967. The second column of the table indicates the number of institutions with biochemistry departments in each group. Columns three through eight show the total number of research doctorates granted in the reference periods 1953-1957, 1958-1962, and 1963-1967 by departments in each group and by the average doctorate production per department over each five-year period. The last two columns indicate the increment in average number of research doctorates granted per department between 1958-1962 and 1963-1967 in both percentage and absolute numbers. The sections of the table for biophysics and pathology are organized in the same manner.[17]

Figure 9 summarizes the major findings. In all cases, the gain in average PhD production per department between 1958-1962 and 1963-1967 was markedly greater for the NIGMS-supported than for non-NIGMS-supported departments when matched for field and for PhD production in 1953-1957. In biochemistry, small PhD-producing departments with support increased their average output by 8.2 PhD's, compared with 2.9 for the non-NIGMS-supported departments. Corresponding increments for departments that were non-PhD-producers in the reference period 1953-1957 were 8.8 and 2.7. Similar results were found for biophysics and pathology. Since all of the large PhD-producing departments received support, a comparison with nonsupported departments in this category is not possible.

The data indicate that the impact of NIGMS support on departmental PhD production varied with the size of department. In biochemistry, the smaller departments (small PhD-producers and non-PhD-producers 1953-1957) showed greater absolute and percentage gains in PhD production than the large departments. In biophysics and pathology, the initially large PhD-producing departments showed greater absolute gains, but the percentage increases were greater in the smaller departments.

Clearly, those departments with NIGMS training grants experienced greater increments in production of research doctorates than did departments without such support. However, the role of NIGMS training grants on the increased production cannot be established with certainty. Training grants were awarded, in general, to the more prestigious and active departments. Therefore, it is not clear whether the training grants were instrumental in bringing about growth or whether the grants were simply given to departments that were already in a process of rapid increase in PhD output. Both factors were probably operative, and the training grants should be credited for having a positive effect—but not the only effect. In interpreting the data in Table 10, it must be noted that the NIGMS support to the department may have been for as little as a few years or for as long as ten years, and the amount may have been as little as a few thousand dollars or as much as $200,000 a year.

Graduate Enrollments

Another measure of the effect of training grants can be seen in Table 11 and Figure 10, which show trends in graduate enrollments in departments with and without training grants. The total number of full-time students in biochemistry departments with NIGMS support increased from 798 in 1960 to 1,510 in 1965, while the corresponding numbers for biochemistry departments without NIGMS support were 224 and 349, respectively. This represents a marked difference in the rate of increase for the two groups of

[17]Physiology was omitted from this table because a change in the academic specialities list used with the Survey of Earned Doctorates introduced a discontinuity in the trend data for physiology during the period covered.

TABLE 11
Graduate Enrollment in Biochemistry versus Botany and Zoology in PhD-Granting Institutions with and without NIGMS Support in Biochemistry[a]

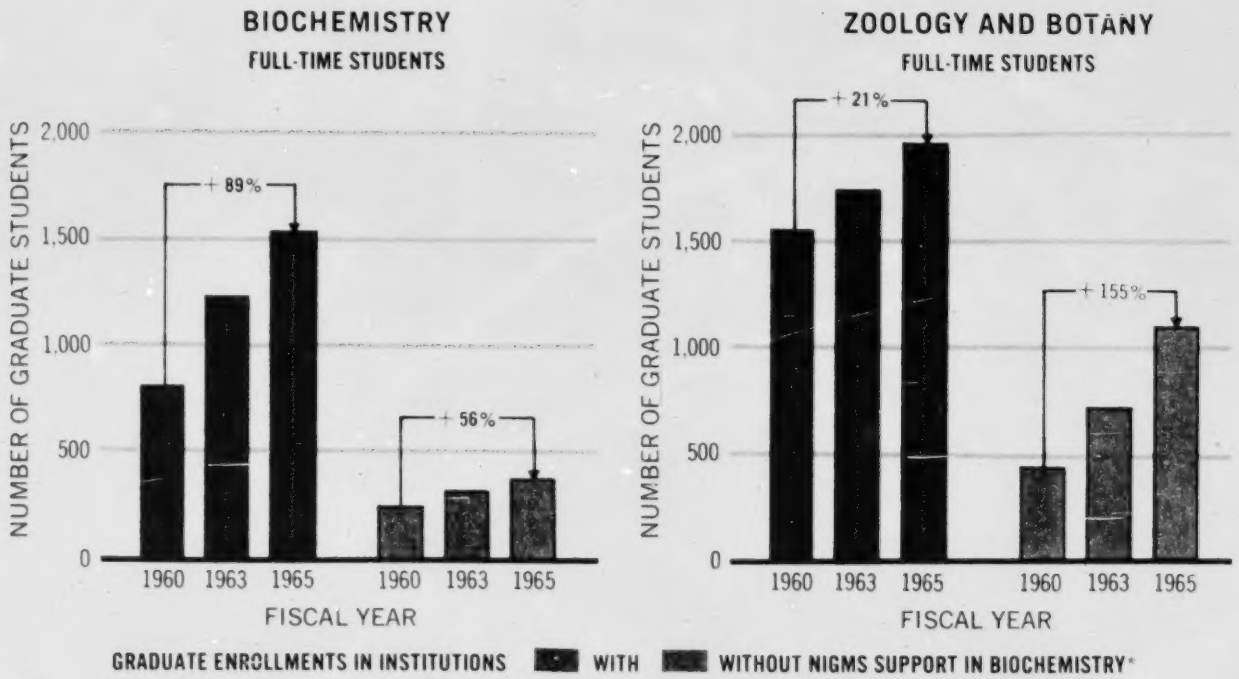
Academic Level in Graduate School[a]	Number of Full-time Graduate Students Enrolled in Institutions				Number of Part-time Graduate Students Enrolled in Institutions			
	With NIGMS Support in Biochemistry[b]		Without NIGMS Support in Biochemistry[b]		With NIGMS Support in Biochemistry[a]		Without NIGMS Support in Biochemistry[a]	
	Biochemistry	Botany and Zoology	Biochemistry	Botany and Zoology	Biochemistry	Botany and Zoology	Biochemistry	Botany and Zoology
FISCAL YEAR 1960								
TOTAL	798	1,534	224	421	350	694	181	265
First Year	359	688	99	237	121	225	68	101
Intermediate	321	685	94	156	196	360	93	137
Terminal	118	161	31	28	33	109	20	27
FISCAL YEAR 1963								
TOTAL	1,201	1,728	298	698	304	731	139	345
First Year	395	678	113	360	90	238	77	139
Intermediate	645	894	153	277	161	390	42	176
Terminal	161	156	32	61	53	103	20	30
FISCAL YEAR 1965								
TOTAL	1,510	1,958	349	1,088	378	821	194	574
First Year	584	847	134	571	141	303	89	255
Intermediate	729	918	176	436	180	423	71	277
Terminal	197	193	39	81	57	95	34	42

[a] *In the annual fall surveys of graduate enrollment, the U.S. Office of Education defined first-year students as those who had completed less than one full year of required study for an advanced degree (or toward the first professional degree). Terminal students were those expected to complete all doctoral requirements (or all requirements for the professional degree) by the following June 30th. Intermediate students were those falling between the two extremes.*

[b] *NIGMS provides little direct support for botany and zoology. Therefore, these fields were selected as controls for comparison with enrollment trends in biochemistry. Institutional groupings "With NIGMS Support" and "Without NIGMS Support" are based on* biochemistry *support.*

Source: *U.S. Office of Education,* Enrollment for Advanced Degrees.

FIGURE 10
Graduate enrollment in biochemistry versus botany and zoology in PhD-granting institutions with and without NIGMS support in biochemistry,* 1960, 1963, 1965.



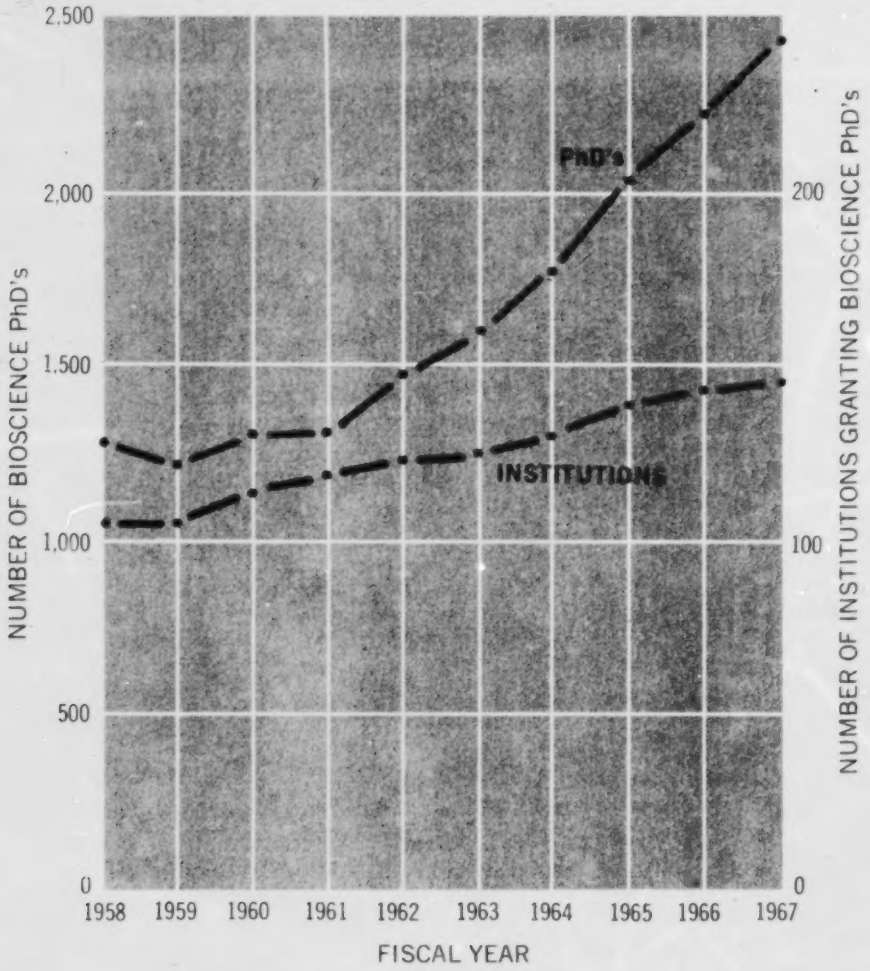
* See note "a" in Table 11.

Source: United States Office of Education, Enrollment for Advanced Degrees. NIGMS, Statement of Appointment of Trainee.

departments. During the same period, graduate enrollment of part-time biochemistry students remained almost constant in both supported and nonsupported departments.

The data in Table 11 also suggest that the positive effect of NIGMS training grant programs on biochemistry graduate student enrollment is not simply a result of over-all institutional increase of graduate students. Information is given for graduate enrollment trends for botany and zoology, science departments not directly supported by NIGMS training grants and selected as control groups for comparison with biochemistry. Botany and zoology enrollments in institutions having NIGMS support *in biochemistry* are listed as "with NIGMS support"; botany and zoology enrollments in institutions without NIGMS support *in biochemistry* are listed as "without NIGMS support." The total number of full-time students in botany and zoology departments in institutions without NIGMS support actually increased more than corresponding enrollments in institutions with NIGMS support. Thus, the number of full-time botany and zoology graduate students in non-NIGMS-supported institutions increased 158 percent (from 421 to 1,088 during the period 1960-1965, while the corresponding increase for botany and zoology in institutions with NIGMS support was only 28 percent (1,534 to 1,958). This finding makes the positive effect of NIGMS training grants on graduate enrollment in biochemistry departments appear to be even more significant. Caution must again be exercised, however, in interpreting the effects of training grants on graduate enrollment.

FIGURE 11
Number of bioscience PhD's and number of institutions granting bioscience PhD's, fiscal years 1958-1967.



Source: National Research Council Office of Scientific Personnel, Doctorate Records File.

The period of NIGMS training grants coincides with an era of rapid growth in numbers of institutions granting PhD's in the biosciences (Figure 11). During the decade 1958-1967, the number increased from slightly over 100 to almost 150. Although not all the growth can be directly attributed to NIGMS training support, it was one factor enabling this dramatic increase in centers for biomedical research training.

Faculty and Scientific Environment

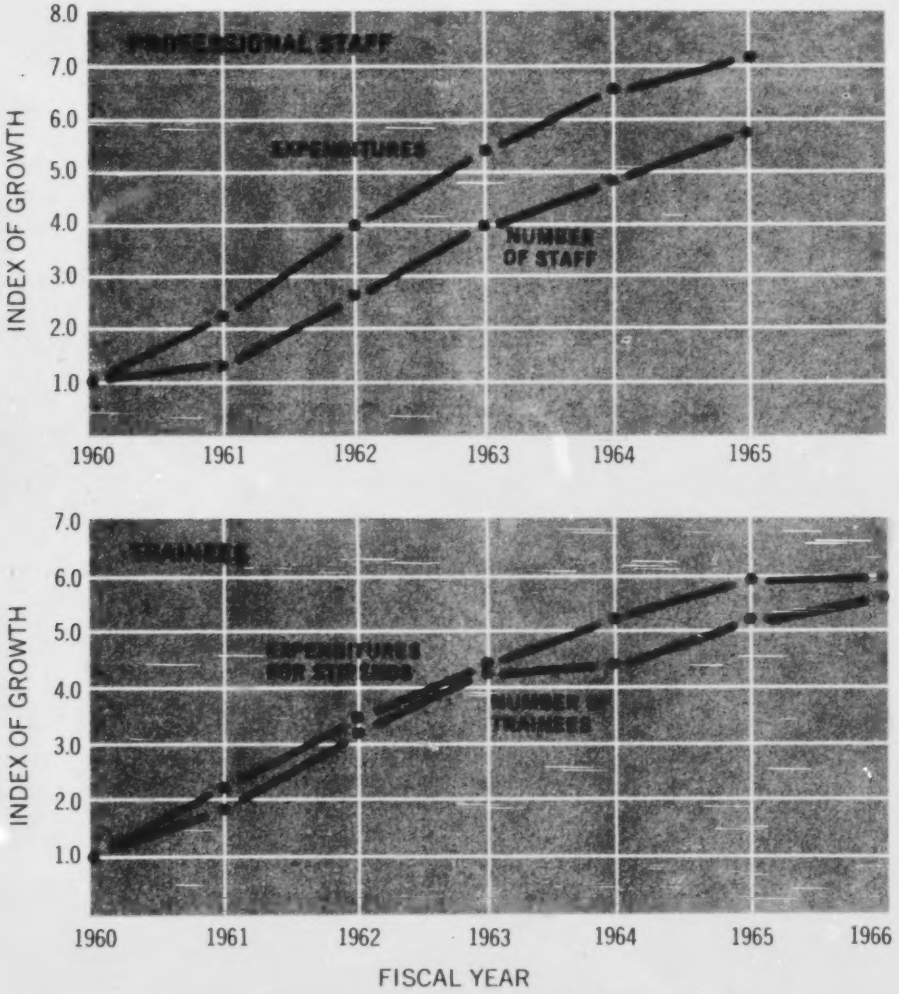
Although it was possible to obtain some measure of the influence of training grants on the numbers of research doctorates produced, it was much more difficult to quantify their effect on the total scientific environment of institutions. It is the opinion of the committee that NIGMS training grants have had a real effect in strengthening the departments within universities. However, so many uncontrollable variables enter into any retrospective

attempt to develop meaningful objective criteria that, in many instances, it has been necessary to fall back on individual illustrative examples.

Undoubtedly, one of the very first beneficial effects within an institution or a department has been the necessity, in preparing a training grant application, to consider in detail both the goals and the organization of the on-going or proposed research training program. The act of committing to paper exactly what a department is doing or proposes to do in training young scientists in a given specialty has necessarily produced critical re-examination of many accepted ideas and the evolution of many new ones

FIGURE 12

Growth rates in staff and expenditures for staff and growth rates in trainees and stipends for trainees, by fiscal year 1960-1965 (fields of biochemistry, biophysics, physiology, and pathology combined).



Note: Index 1.0 = Numbers of professional staff and trainees in 1960. / Total expenditures for staff and trainees in 1960.

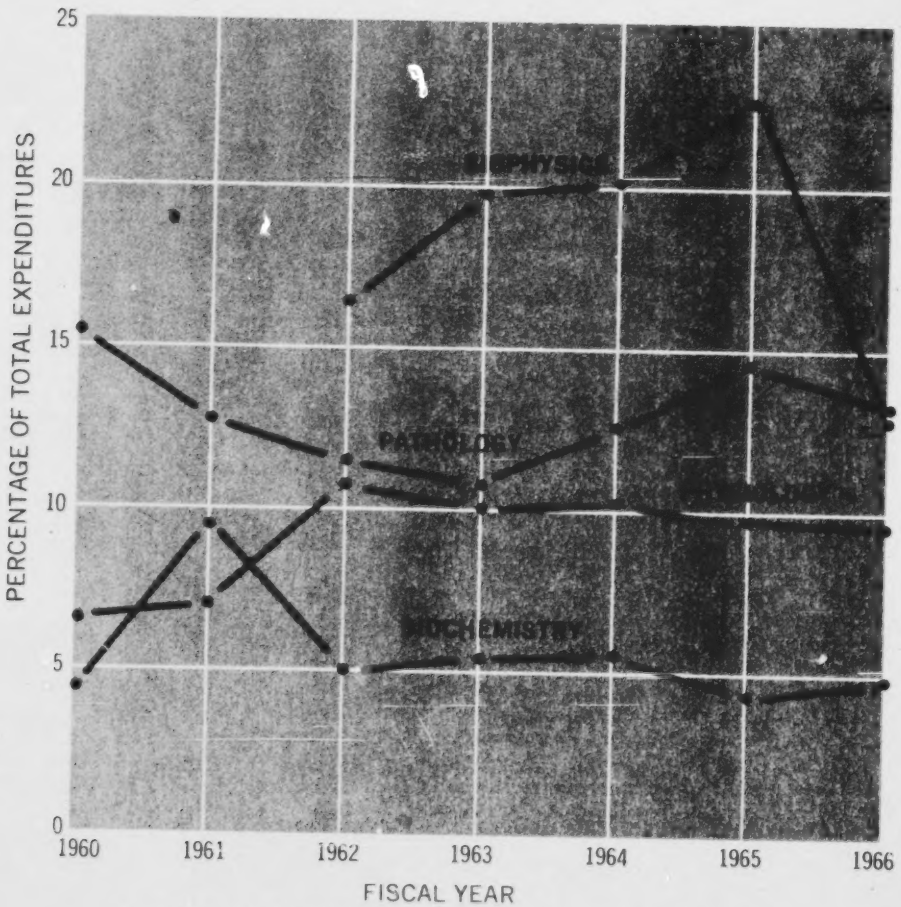
Source: NIGMS, Report of Expenditures-Training Grant Program.

—a healthy phenomenon in any endeavor. Extracts from program directors' comments strongly suggest that from such considerations, on-going programs have been markedly changed and totally new ones have been introduced.

NIGMS training grants have provided the means of increasing faculty size by providing direct support for faculty salaries, both for those faculty members directly involved in administering the grant-supported programs, and for new members added to enhance over-all capacity in research training either through their teaching skills or their special areas of research interest.

In Figure 12, the over-all steady growth of professional staff supported by NIGMS training grants in the combined areas of biochemistry, biophysics, physiology, and pathology between 1960 and 1965 is indicated. Special factors have resulted in the somewhat differing importance of professional staff expenditures in the support picture of each of these areas as shown in Figure 13. In biochemistry and physiology, established fields with a

FIGURE 13
Expenditures for professional staff as a percentage of total training grant expenditures, by field, fiscal years 1960-1966.



Source: NIGMS, Report of Expenditures-Training Grant Program.

long experience in graduate training, only 5 to 10 percent of the training grant funds were used to increase the faculty. In biophysics, an emerging specialty in which new programs are being established, and in pathology, a field with little previous experience in full-time research training programs, 15 to 20 percent of the funds were utilized to establish the needed faculty support. The generally higher compensation levels of faculty members in pathology (usually MD's), compared with the levels in other fields examined, also contributed to the high percentage of training grant funds used for faculty salaries in this field.

The impact of NIGMS training grants on total numbers of faculty in each department is difficult to quantify because the records do not show whether the faculty members directly supported by the grants are new in the department. In general, the faculty supported by NIGMS training grants do represent actual *additions* to the total faculty since the total faculty size has increased more rapidly in departments with NIGMS support than in the non-NIGMS-supported departments (see Table 12). It should be noted that training grant funds not only permit the addition to departments of new

TABLE 12

Trends in Numbers of Professional Staff, NIGMS-Supported versus Non-NIGMS-Supported Departments[a]

Training Field	Years of NIGMS Support to Departments (1958-1967)	Number of Professional Staff			Percentage Increment in Professional Staff from 1957 to 1965
		1957	1960	1965	
BIOCHEMISTRY	**TOTAL**	**312**	**311**	**373**	**20**
	1-4 years Support	40	46	49	22
	⩾5 years Support	230	227	278	21
	Non-NIGMS-Supported Departments	42	38	46	10
BIOPHYSICS	**TOTAL**	**20**	**25**	**39**	**95**
	1-4 years Support	—	—	—	—
	⩾5 years Support	14	18	32	128
	Non-NIGMS-Supported Departments	6	7	7	17
PATHOLOGY	**TOTAL**	**55**	**48**	**68**	**24**
	1-4 years Support	25	12	21	−16
	⩾5 years Support	18	23	29	61
	Non-NIGMS-Supported Departments	8	6	8	0
PHYSIOLOGY	**TOTAL**	**226**	**228**	**301**	**33**
	1-4 years Support	43	45	59	37
	⩾ 5 years Support	102	112	159	56
	Non-NIGMS-Supported Departments	81	71	83	2

[a] *The data are based on information from those institutions that reported regularly and completely to the American Council on Education surveys.*

Source: *NIGMS, Statement of Appointment of Trainee.*

American Council on Education, A Guide to Graduate Study, *1957, 1960, and 1965 editions.*

faculty members, but also of such support personnel as technicians, secretaries, administrative assistants, and instrumentation experts, who contribute to an over-all increase in research training capability.

The breadth of the educational experience of the trainees has been increased by enabling the department to pay for visiting seminar speakers and to send trainees to national scientific meetings. Although a definite causal relationship cannot be established between the grant and the quality of faculty and the training program, the following extracts from the comments of program directors in their progress reports to NIGMS are suggestive of a beneficial effect:

> [As to] the impact the program has had on the department, it can be safely said that the teaching of graduate students continues to be a source of stimulation to staff men in terms of amplifying their research interests and broadening their knowledge in the particular areas which they are asked to present as advance courses in physiology . . . . The addition of graduate training to the program of professional instruction has rather significantly changed the climate of research interest here, and for this, training grant support to this department and to other departments of the school must be given the direct credit.
>
> The training grant has helped in strengthening our program by making it possible to add to staff. With increase in personnel at a teaching level we have been able to increase the number and the quality of advanced courses and to increase guidance and leadership for research work by graduate students.
>
> The effect of the existence of such a program, and the thought and activities required for its implementation, upon departmental staff and secondarily, upon the entire institution beyond the Graduate School itself, are profound . . . . Greater numbers of research projects with broadened scope, the increased alertness and dedication which attends contact with developing graduate students, . . . all add up to an enriched scientific scheme. Loss of the program would make its erstwhile impact plainly evident, one may be sure.

Physical Facilities

In addition to increasing the numbers of faculty and students in recipient departments, the NIGMS training grants have, in many instances, helped to provide the tools required by these individuals to carry out a modern and productive research training program. Data collected from a 50 percent sample of the Reports of Expenditures submitted by program directors of training grants in the fields of biochemistry, biophysics, physiology, and pathology show that purchases of equipment and supplies accounted for one fourth of all expenditures in fiscal year 1959. By fiscal year 1967, the funds used for equipment had decreased to one tenth of the total grant, but the absolute dollar amount had quadrupled over the earlier year. These funds made it possible to obtain not only supplies for trainees, but large pieces of equipment for joint use by a number of trainees and staff members. Thus, the over-all research training potential of a department was enhanced through the acquisition of equipment that could not have been justified on an individual member's research grant. Although in some instances such equipment might have been obtained through special grants or general research support funds, there is no question that in many cases the training grants provided the only readily available sources, a point that is reiterated in program directors' comments:

> An additional, but by no means secondary feature, is the financial freedom which allows us to purchase needed equipment for instruction, to schedule seminars by outstanding biochemists, and to offer competitive salary levels to trainees.

> As a result of the Training Grant and another research grant a well-equipped group of laboratories with all the necessary facilities have been provided. . . .The Training Program has enabled the creation of a new research atmosphere in the department and the formation of a group of people who are primarily interested in research.

New Fields of Biomedical Science

An important effect of the NIGMS training grant program has been the encouragement of new departments and new interdisciplinary programs that do not fit into classical administrative alignments. Biomedical research and research training have been enhanced by the continuing development of programs in biophysics, genetics, and biometrics that cut across old departmental lines and speed the application of diverse skills to common problems.

The following types of comments appeared quite regularly in reports from the program directors:

> This program is unquestionably the strongest unifying influence in our departmental activities. It provides support and motivation for interaction of different staff members, the trainees, and in many cases, persons from other departments or institutions. It would be entirely fair to say that without this program, this would be a different type of department and a much less effective one.

> The work in the field of nutritional pathology has been disseminated to staff members and to veterinary students. This has resulted in an appreciation of the great variety of changes which result from malnutrition. The general result has been an upgrading of veterinary pathology.

> It has been difficult to find support from sources geared to the classical disciplines and therefore the training program has made possible the development of a multi-disciplinary approach.

The number of degrees granted and the magnitude of NIGMS training grant support in some of these new fields are presented in Table 13. Although biophysics is perhaps the most striking example of the effect of NIGMS support on an emerging specialty, it is clear that a number of other areas were also affected. Two program directors stated:

> We have previously stressed the flexibility that this program provides and we would re-emphasize this as being extraordinarily important to us. In particular, we believe that the program allows trainees to gain experience in various areas of biochemistry before selecting a specific field of concentration. Direct support from outside agencies to trainees is more properly linked to the selection of thesis work by the trainee. The training program in the department urges students to seek such outside direct support as soon as their thinking has advanced to the point where they can wisely select their field of concentration.

> As a recently organized (1960) Department of Biochemistry and Biophysics, we may be relatively unique in the benefits which we are deriving from this Training Program. We visualize it as providing us with 1) an opportunity for *broader, more intensive, and more rapid* training of incoming students, . . . 3) it is more economic of research funds, since a) the basic intensive training results in a better comprehension of tools available for research, and, simultaneously, the student has learned how to use those tools.

Clinical Research Training

Finally, the effect of NIGMS training grant support on pre- and post-MD research training should be noted. Although the major emphasis in this

TABLE 13

Number of Research Doctorates Granted and Stipend and Dependency Support for NIGMS Trainees and Fellows in Five Bioscience Fields, Fiscal Years 1958-1967

Fiscal Year	Biophysics		Biometrics		Genetics		Pharmacology		Pathology	
	PhD's Number	Stipend and Dependency Dollars	PhD's Number	Stipend and Dependency Dollars	PhD's Number	Stipend and Dependency Dollars	PhD's Number	Stipend and Dependency Dollars	PhD's Number	Stipend and Dependency Dollars
1958	21	100	3	112,240	71	110	48	700	14	51,270
1959	23	21,880	3	215,760	75	60,840	40	118,275	14	307,575
1960	23	109,510	11	274,698	74	240,765	53	291,328	11	556,350
1961	25	215,218	7	327,103	73	436,259	49	459,343	22	681,889
1962	33	873,191	10	585,675	81	1,039,647	74	701,161	23	1,210,667
1963	36	1,481,877	14	665,520	97	1,256,166	70	1,072,951	21	1,546,915
1964	40	1,705,189	22	867,200	98	1,355,785	89	1,212,231	31	1,752,551
1965	54	1,586,204	24	1,038,763	102	1,371,956	97	1,390,097	36	1,934,358
1966	83	1,645,659	20	1,075,034	113	1,553,981	104	1,447,423	37	1,906,867
1967	90	1,458,457	25	1,027,642	142	1,433,384	112	1,491,767	46	1,984,126

Source: *National Research Council, Office of Scientific Personnel, Doctorate Records File.*

NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.

Note: *The number of PhD's is the U.S. total for each field. The dollar amount refers to NIGMS support in the field.*

report has been on PhD training, in part because of its ready quantification, significant research training has been provided to many individuals who do not obtain the PhD. For instance, although training-grant-supported institutions have been favorably influenced in the number of PhD's in pathology produced (see Table 13), the totals are so small that the expenditures might be considered wasted if only those receiving PhD degrees were considered. In fact, many more individuals have been provided with an opportunity for several years of post-MD research training not previously available under the standard pathology residency programs. Such individuals are now beginning to provide a supply of adequately trained experimental pathologists for academic careers. Examples of such post-training appointments appeared frequently in reports to NIGMS by program directors in pathology departments. After listing three former trainees known to have advanced in academic rank in the past year, one program director concluded:

> These and other former trainees who have remained in academic positions have continued to be productive investigators as well as teachers, as reflected in their various publications during the past year.

Another director cited the following example:

> As a result of his training in research in this program, Dr. _____, after returning to clinical practice in orthopedic surgery, felt that the clinical sciences were greatly lacking in a scientific approach to their problems. After four months, he returned to research in the program and plans a career in research in Experimental Pathology.

A third program director noted:

> There was a striking increase of interest in research activities. This manifested itself not only in the trainees but in the service staff of the Department . . . . The program also had a stimulating effect on the residents in our department. Their interest in experimental research has risen.

SUMMARY

- NIGMS support for graduate training in the biomedical sciences through traineeship programs and fellowship programs varies by academic field. The amount of stipend and dependency support, the percentage of doctorate-granting departments having NIGMS trainees, and the median total months of support supplied to students all reveal a great deal of variation among the different bioscience fields.

- Regional distribution of NIGMS funds and graduate student support, when compared with bioscience PhD production and graduate student enrollment, showed the New England and Middle Atlantic states receiving proportionately more than the West North Central, West South Central, and Mountain states. Likewise, private institutions received proportionately more NIGMS support than public ones. It should be noted that balanced geographical distribution was not a goal of the research training programs.

- Almost one third of the fiscal year 1967 bioscience PhD's had received NIGMS traineeship support at some time during their graduate programs, and in certain subfields, over half the PhD recipients had received such support.

- Comparisons between departments having NIGMS training grant support and departments in matched fields without such support show that:

  The gain in average PhD production per department between 1958-1962 and 1963-1967 was markedly greater for the NIGMS-supported departments than for non-NIGMS-supported ones.

  Smaller departments show the greater percentage increases in PhD production as a result of NIGMS grants, but larger departments show comparable gains in absolute numbers of doctorates granted.

  Full-time graduate student enrollment in biochemistry departments with NIGMS support increased much more rapidly than corresponding enrollment in biochemistry departments without support (1960-1965). Non-supported fields (botany and zoology) in the same institutions did not show these differences.

  The number of PhD-granting departments in the biosciences increased by one third during the decade covered by the study.

  Not all these differences should be attributed directly to NIGMS training grant support, but this was one major factor enabling recipient departments to grow as rapidly as they did.

- Although difficult to quantify, the favorable impact of training grants on recipient bioscience departments appears clear. Anecdotal reports of program directors, and the personal knowledge of the committee members, indicate a positive effect on faculty, curriculum, and physical facilities in many departments. Faculties have been increased, new courses have been offered, and important items of equipment have been obtained through training grant support. Thus, in addition to producing more PhD's, the training grants have served to strengthen the departments from which the graduates have come.

CHAPTER IV

TRAINING GRANT SUPPORT AND IMPACT: BIOSCIENCE GRADUATE STUDENTS

PATTERNS OF NIGMS SUPPORT TO BIOSCIENCE GRADUATE STUDENTS

Numbers and Characteristics of Those Supported
Amount of Support
Other Sources of Support

IMPACT OF SUPPORT ON BIOSCIENCE STUDENTS

Time Lapse to PhD
PhD Attainment Rate
Field Switching
Post-training Careers

SUMMARY

PATTERNS OF NIGMS SUPPORT TO BIOSCIENCE GRADUATE STUDENTS

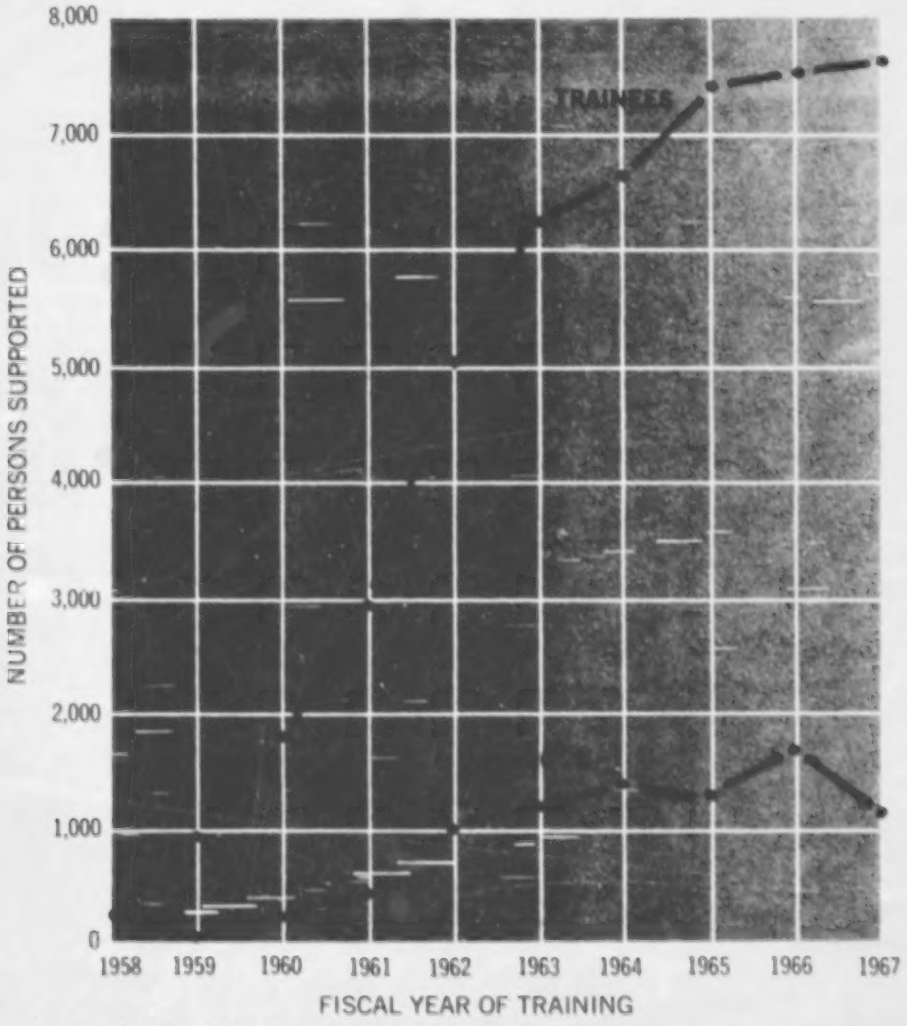
Figure 14 shows the growth in numbers of NIGMS trainees and fellows supported in each year since 1958. After an initial period of rapid growth, both programs leveled off, supporting about 7,700 trainees and about 1,100 fellows annually.

During the ten-year period covered by this study, a total of 28,503 bioscience students received NIGMS support. Of these, 23,380 received traineeship support only; 3,759 received fellowship support only; and 1,364 received both traineeship and fellowship support. However, since the major interest of this study was to evaluate the effects of traineeship and fellowship programs, most of the following tables show just two groups—trainees and fellows. The 1,364 trainee-fellows are included in both groups.

Numbers and Characteristics of those Supported

Table 14 summarizes some of the characteristics of the 24,744 persons who had received traineeships (23,380 plus 1,364) and the 5,123 who had received fellowships (3,759 plus 1,364). Virtually all are U.S. citizens, four out of five are male, and slightly less than half are single. About half of the trainees and two thirds of the fellows were pre-PhD s at the time of their

FIGURE 14
Number of NIGMS trainees and fellows, fiscal years 1958-1967.



Source: NIGMS, Statement of Appointment of Trainee and Fellowship Award Statement.

first appointment. Fellows were about two years older than the trainees, reflecting the fact that nominations for fellowships usually occurred later in the academic program.

A more detailed description of the trainees and fellows by academic level and field of study is available in Tables 15 and 16. For both groups in more clinically-oriented basic sciences such as pathology, most of the students were pre- or post-MD, while in the laboratory-oriented basic medical sciences such as biochemistry, physiology, and microbiology, a large proportion were at the pre-PhD level. Chemistry was a big field at the pre- and post-PhD levels for the fellows, but was virtually nonsupported for trainees. Special note should be made of the category "medical student" in the trainee table. These were medical students who received short periods of research training—typically, for a 3-month summer period. Therefore, while

TABLE 14

Summary Description of NIGMS Trainees and Fellows, Fiscal Years 1958-1967

	Trainees	Fellows
TOTAL	24,744	5,123
U.S. CITIZENS	92%	97%
MALE	81%	81%
SINGLE	42%	32%
ACADEMIC LEVEL AT FIRST AWARD		
Pre-PhD	48%	65%
Pre-MD	26	–
Post-MD	11	5
Post-PhD	5	19
Other	9	11
MEDIAN AGE AT FIRST AWARD	25.2 years	27.6 years
HIGHEST DEGREE AT FIRST AWARD		
Baccalaureate	69%	49%
Master's	15	27
Research doctorate	5	19
Professional doctorate	11	5
MEDIAN TOTAL LENGTH OF SUPPORT	10.3 months	12.4 months
TRAINING FIELDS AT FIRST AWARD		
Biochemistry	14%	19%
Pathology	10	1
Physiology	7	10
Microbiology	6	9
Pharmacology	6	3
Biometrics	6	1
Anatomy	5	3
Biophysics	5	9
Genetics	5	6
Other Biosciences	8	10
Chemistry	–	21
Physical Sciences & Engineering	1	2
Health Sciences	4	2
Medical Students	18	–
Other	5	4
MEDIAN TOTAL AMOUNT OF STIPEND AND DEPENDENCY ALLOWANCE	$2,210	$5,500

Source: NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.

they accounted for a large proportion of the trainees (18.2 percent), they received only a small proportion of the traineeship funds.

Amount of Support

The amount of NIGMS support to trainees and fellows may be analyzed by *months* of support supplied or by stipend and dependency *dollars* received by the students. In either case, it is important to distinguish between the amount of *support received during a given fiscal year* and the *total support* received, summed over all years. Table 17 shows the median months of support and median stipend and dependency support received by trainees and fellows during each fiscal year. Table 18 shows median total months and median total stipend and dependency support received, summed over all years.

TABLE 15

Number of NIGMS Trainees, by Field of Training and Academic Level, Fiscal Years 1958-1967

Field of Training	Total		Number of Trainees by Academic Level[a]									
			Pre-PhD		Pre-MD		Post-MD		Post-PhD		Other	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
TOTAL All Fields	24,744	**100 (100)**	11,959	**100 (48)**	6,521	**100 (26)**	2,699	**100 (11)**	1,331	**100 (5)**	2,234	**100 (9)**
BIOCHEMISTRY	3,343	14	2,678	22	148	2	100	4	307	23	110	5
PATHOLOGY	2,449	10	192	2	911	14	1,083	40	58	4	205	9
PHYSIOLOGY	1,680	7	1,218	10	136	2	138	5	66	5	122	6
MICROBIOLOGY	1,594	6	1,249	11	81	1	67	3	105	8	92	4
PHARMACOLOGY	1,383	6	876	7	169	3	95	4	93	7	150	7
BIOMETRICS	1,489	6	925	8	56	1	117	4	85	6	306	14
ANATOMY	1,214	5	725	6	261	4	93	3	78	6	57	3
BIOPHYSICS	1,226	5	873	7	57	1	83	3	134	10	79	4
GENETICS	1,296	5	860	7	85	1	92	3	155	12	104	5
OTHER BIOSCIENCE	1,996	8	1,000	8	481	7	230	9	113	8	172	8
CHEMISTRY	110	–	83	1	4	–	4	–	7	–	12	–
PHYSICAL SCIENCES AND ENGINEERING	208	1	190	2	3	–	6	–	3	–	6	–
HEALTH SCIENCES	1,030	4	325	3	211	3	415	15	47	4	32	1
MEDICAL STUDENT	4,514	18	139	1	3,890	60	46	2	18	1	421	19
ALL OTHER	1,200	5	616	5	28	–	129	5	61	5	366	16
UNKNOWN	12	–	10	–	–	–	1	–	1	–	–	–

[a] *Percentages may not sum to 100 because of rounding. The percentage of trainees by academic level, all fields combined, is shown in parentheses.*

Source: NIGMS, Statement of Appointment of Trainee.

TABLE 16

Number of NIGMS Fellows, by Field of Fellowship and Academic Level, Fiscal Years 1959-1967

Field of Training	Total		Number of Fellows by Academic Level[a]							
			Pre-PhD		Post-MD		Post-PhD		Other	
	No.	%	No.	%	No.	%	No.	%	No.	%
TOTAL All Fields	5,123	**100 (100)**	3,361	**100 (65)**	247	**100 (5)**	966	**100 (19)**	549	**100 (11)**
BIOCHEMISTRY	979	19	523	16	46	19	280	30	130	24
PATHOLOGY	30	1	14	–	13	5	1	–	2	–
PHYSIOLOGY	538	10	365	11	32	13	58	6	83	15
MICROBIOLOGY	485	10	342	10	13	5	62	6	68	12
PHARMACOLOGY	132	3	88	3	13	5	21	2	10	2
BIOMETRICS	60	1	35	1	7	3	8	1	10	2
ANATOMY	132	3	96	3	8	3	19	2	9	2
BIOPHYSICS	453	9	274	8	12	5	137	14	30	6
GENETICS	295	6	156	5	17	7	86	9	36	7
OTHER BIOSCIENCE	524	10	369	11	7	3	89	9	59	11
CHEMISTRY	1,077	21	807	24	4	2	193	20	73	13
PHYSICAL SCIENCES AND ENGINEERING	105	2	90	3	8	3	3	–	4	1
HEALTH SCIENCES	108	2	57	2	42	17	3	–	6	1
ALL OTHER	198	4	144	4	25	10	6	1	23	4
UNKNOWN	7	–	1	–	–	–	–	–	6	1

[a] *Percentages may not sum to 100 because of rounding. The percentage of fellows by academic level, all fields combined, is shown in parentheses.*

Source: *NIGMS, Fellowship Award Statements.*

TABLE 17

Median Months of Support and Median Amount of Stipend and Dependency Allowance Received in Each Year by Trainees and Fellows, by Academic Level, Fiscal Years 1958-1967

Academic Level	Trainees										Fellows								
	1958	1959	1960	1961	1962	1963	964	1965	1966	1967	1959	1960	1961	1962	1963	1964	1965	1966	1967
	Median Months of Support Received During the Fiscal Years																		
TOTAL All Levels	**4**	**6**	**6**	**6**	**6**	**7**	**9**	**9**	**10**	**10**	**6**	**9**	**12**	**12**	**12**	**12**	**12**	**12**	**12**
PRE-PhD	5	8	8	7	10	10	10	10	10	12	4	12	12	12	12	12	12	12	12
PRE-MD	1	2	2	2	2	2	2	3	2	2									
POST-MD	6	10	10	10	11	12	12	12	12	12	5	12	12	12	12	12	12	12	12
POST-PhD	10	6	6	7	8	8	8	8	8	10	8	2	12	12	12	12	12	12	12
OTHER	6	4	3	2	2	2	2	3	2	3	0	3	12	12	12	12	12	12	12
	Median Stipend and Dependency Allowance Received During the Fiscal Year																		
TOTAL All Levels	**$ 570**	**$ 980**	**$1,220**	**$1,110**	**$1,300**	**$1,430**	**$1,860**	**$1,960**	**$2,040**	**$2,240**	**$4,500**	**$4,210**	**$2,830**	**$3,140**	**$3,180**	**$3,210**	**$3,360**	**$3,400**	**$3,200**
PRE-PhD	690	1,200	1,430	1,530	1,870	2,070	2,250	2,350	2,300	2,510	3,500	3,180	3,080	2,780	2,760	2,740	3,010	3,060	2,950
PRE-MD	310	450	640	390	480	540	740	770	770	770									
POST-MD	1,560	2,480	3,070	3,040	3,590	4,080	4,560	4,900	4,970	6,090	6,630	6,330	7,210	7,080	7,310	7,560	7,540	7,360	9,250
POST-PhD	3,400	2,540	2,800	3,130	3,270	3,590	3,790	3,780	3,760	4,260	6,000	5,520	5,480	5,980	6,420	6,540	6,700	6,320	5,940
OTHER	360	340	410	390	420	420	670	780	800	780	---	750	2,470	2,680	2,840	3,530	5,500	5,570	6,000

Source: *NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.*

TABLE 18

Median TOTAL Months of Support and Median TOTAL Stipend and Dependency Allowance Received by Trainees and Fellows by Academic Level and Fiscal Year of First Award

Academic Level	Trainees										Fellows								
	1958	1959	1960	1961	1962	1963	1964	1965	1966[a]	1967[a]	1959	1960	1961	1962	1963	1964	1965	1966[a]	1967[a]
	Median TOTAL Months of Support Received by Fiscal Year of First Award																		
TOTAL All Levels	**13**	**12**	**12**	**11**	**12**	**11**	**11**	**10**	**10**	**8**	**6**	**11**	**20**	**21**	**23**	**23**	**23**	**12**	**12**
PRE-PhD	15	18	21	17	19	21	19	19	17	11	4	13	21	22	24	24	23	12	12
PRE-MD	6	5	5	4	4	4	4	4	3	3									
POST-MD	18	13	15	13	13	14	13	14	13	11	6	12	12	23	20	12	12	12	11
PRE-PhD	15	12	12	13	12	12	12	11	11	10	8	10	13	12	13	12	12	12	12
OTHER	12	6	5	9	5	4	5	4	3	3	–	3	21	22	12	12	–	12	–
	Median TOTAL Stipend and Dependency Allowance Received by Fiscal Year of First Award																		
TOTAL All Levels	**$2,750**	**$2,760**	**$3,100**	**$2,570**	**$2,740**	**$2,810**	**$2,830**	**$2,340**	**$2,260**	**$1,720**	**$5,830**	**$5,650**	**$6,620**	**$7,180**	**$7,060**	**$6,310**	**$4,920**	**$3,160**	
POST-PhD	3,230	3,770	4,190	3,870	4,370	4,570	4,280	4,360	3,750	2,170	6,250	6,630	6,120	6,540	6,450	5,890	3,920	2,900	
PRE-MD	1,060	1,000	990	1,040	920	950	880	890	840	730									
POST-MD	6,330	4,750	5,940	5,550	5,800	6,820	6,500	7,530	6,450	6,030	6,500	8,750	15,130	12,790	9,500	10,500	7,900	9,500	
POST-PhD	5,500	4,640	5,060	6,170	5,900	5,900	6,710	5,900	5,430	4,630	10,500	10,600	10,250	10,030	9,580	8,250	6,380	5,940	
OTHER	1,100	490	850	910	960	970	940	930	810	670	750	4,770	5,180	4,500	4,330	---	3,000	---	

[a]*Many persons receiving support for the first time in fiscal year 1966 or 1967 will receive additional support in 1968 or later. Therefore, the medians for these years are not comparable with those for 1965 and earlier years.*

Source: *NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.*

For trainees, the median months of support per year increased steadily for all academic levels except pre-MD, reaching 9-12 months per year by 1964. The median fellowship support has been 12 months per year since 1961. Consequently, the rapid increments in median dollars of stipend and dependency support for trainees between 1958 and 1963 reflect both changes in stipend level and increases in average months of support per year. After 1964 for trainees and after 1961 for fellows, the increases in dollar support represent primarily increases in stipend level. Basic stipends (for a 12-month period) of predoctoral trainees and fellows have been fixed since July 1, 1965, at the following levels:

First-year predoctoral trainee or fellow	$2,400
Second-year predoctoral trainee or fellow	$2,600
Third-year predoctoral trainee or fellow	$2,800

Persons appointed for less than 12 months "will be supported at the appropriate stipend level on a pro rata basis." Postdoctoral stipends for a 12-month period for trainees and fellows are:

With no relevant postdoctoral experience	$6,000
With one year relevant postdoctoral experience	$6,500
With two or more years relevant postdoctoral experience	$7,000

In addition to the stipend, allowances may be awarded at predoctoral and postdoctoral levels in the amount of $500 for any dependent who receives more than one half of his or her total support from the trainee.

The median stipend and dependency support received during each fiscal year is tabulated in Table 17. At the pre-PhD level, the fellows receive about $500 more than the trainees because their median months of support/year is longer, because they tend to be in their second or third year of graduate work rather than their first, and because they are more likely to have dependents. At the postdoctoral level, the post-MD stipend and dependency support is about $1,000/year more than that for post-PhD's.

From Table 18, it is apparent that pre-PhD's have the longest median duration of support when summed over all years of support. They receive an average of two academic years of support compared with an average of one year of support for postdoctoral trainees and fellows. As noted above, the pre-MD group of trainees is made up of medical students who receive short-term research experience for one or two summers.

Are these stipend and dependency allowances adequate? The median stipend and dependency income for pre-PhD trainees in fiscal year 1967 was $2,510, but it is not possible to determine in a strictly objective manner whether this is an adequate level of support because graduate students are not generally classified as employed wage earners. However, a few statistics are available that provide a frame of reference to the financial status of graduate students. About half of the pre-doctoral trainees and fellows are married, and 20 percent of them claim dependent children.[18] In 1965, the per capita income in the United States was $2,746, and in 1965 the median family income was $6,882.[19] Data from the USOE *Survey of the Academic and Financial Status of Graduate Students, Spring 1965*, cited in Chapter I, show that the 17,550 bioscience graduate students of that year had a total income from all sources of $82,450,000, or an average of $4,700 per student.

[18]NIGMS, Program Analysis Branch, *NIGMS Indirect Trainees*, PAB 45b (August 27, 1968), p.10.

[19]U.S. Bureau of the Census, *Statistical Abstract of the United States 1967* (U.S. Government Printing Office, Washington, D.C.), pp. 327 and 333.

TABLE 19

NIGMS Trainee Stipend Levels Compared with Consumer Price Index, Fiscal Years 1958-1968[a]

Fiscal Year	Trainee Stipend Levels: Predoctoral	Trainee Stipend Levels: Postdoctoral	Consumer Price Index
1958	$1,600-2,000	$3,800-4,600	100.7
1959	1,800-2,200	4,500-5,500	101.5
1960	1,800-2,200	4,500-5,500	103.1
1961	1,800-2,200	5,000-6,000	104.2
1962	1,800-2,200	5,000-6,000	105.4
1963	1,800-2,200	5,000-6,000	106.7
1964	1,800-2,200	5,000-6,000	108.1
1965	2,400-2,800	5,000-6,000	109.9
1966	2,400-2,800	5,000-6,000	113.1
1967	2,400-2,800	6,000-7,000	115.0
1968	2,400-2,800	6,000-7,000	121.2
Percentage Increment 1958-1968:	50-40%	58-52%	20%

[a]*Prior to July 1, 1965, project directors could pay stipends at any level justified by "institution policy"; since July 1, 1965, the official stipend levels are maximal.*

Source: *Communication from NIH.*
U.S. Department of Commerce, Statistical Abstract of the U.S., 1967, *p.355.*

TABLE 20

Time-Line Displays for Selected Trainees in Biochemistry, Showing Years of Degrees, Years of NIGMS Support, and Amounts of NIGMS Support

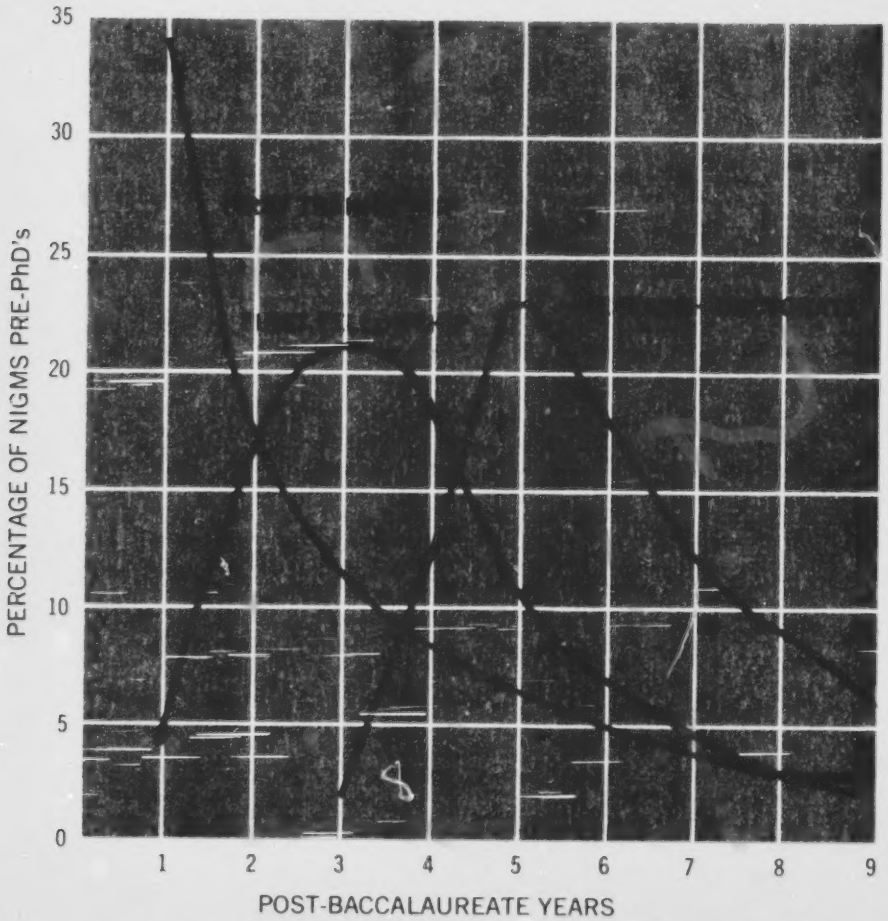
Time-Line for Selected Trainees															Total Amount of Support	Key to Symbols
				B				R								
FY 1953	54	55	56	57	58	59	60	61	62	63	64	65	66	67	T = $15,000	T = Traineeship
									T	T	T					F = Fellowship
						B				M		R				B = Baccalaureate
FY 1953	54	55	56	57	58	59	60	61	62	63	64	65	66	67	T = $2,400	M = Master's
							T	F	F	F	F				F = $9,900	R = Research Doctorate
	B		M									R				D = Professional
FY 1953	54	55	56	57	58	59	60	61	62	63	64	65	66	67	T = $2,496	Doctorate
									T	F	F				F = $5,200	
						B			D							
FY 1953	54	55	56	57	58	59	60	61	62	63	64	65	66	67	T = $4,583	
											T					
										B						
FY 1953	54	55	56	57	58	59	60	61	62	63	64	65	66	67	T = $4,142	
											T	T	F	F	F = $7,200	
									B					R		
FY 1953	54	55	56	57	58	59	60	61	62	63	64	65	66	67	T = $10,500	
										T	T	T	T			
											B					
FY 1953	54	55	56	57	58	59	60	61	62	63	64	65	66	67	T = $1,344	
											T	T	F	F	F = $5,200	
	B															
FY 1953	54	55	56	57	58	59	60	61	62	63	64	65	66	67	T = $14,117	
									T	T	T	T	T	T		

Source: *NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.*

A comparison of NIGMS stipend levels with the Consumer Price Index for the period 1958-1968 (Table 19) shows that predoctoral stipends increased 40-50 percent; postdoctoral stipends increased 50-60 percent; and the Price Index went up about 20 percent over the same period. Although the predoctoral stipend level has increased faster then the Price Index, by 1967 it was still 10 percent below the United States per capita income and only about half the average total income of bioscience graduate students.

In addition to studying the total amounts of NIGMS support, it is useful to investigate the various patterns in which this support is provided. Table 20 summarizes the case histories of a number of persons who received NIGMS support. A "time line" for each person lists the years from 1953 through 1967, and above the line are printed symbols showing the year of receipt of academic degrees (baccalaureate, master's, research doctorate, and professional doctorate). Below the line, a second set of symbols indicates

FIGURE 15
Relationship between year of baccalaureate and year of first NIGMS traineeship, first NIGMS fellowship, and research doctorate, pre-PhD awardees of 1958-1967.



Source: NIGMS, Statement of Appointment of Trainee and Fellowship Award Statement. National Research Council, Office of Scientific Personnel, Doctorate Records File.

years in which traineeship or fellowship support was received. The total dollar amount of the support is tabulated at the end of the line.

The placement of traineeship or fellowship support in the academic career of individual students may be quite different. However, when all records are inspected and tabulated, a rather definite pattern of support becomes generally visible (see Figure 15). If one takes the year of baccalaureate as a reference point, the first traineeship generally comes in the first post-baccalaureate year, and the frequency falls off rapidly for each succeeding year. Note that a person receiving support in his second or third post-baccalaureate year could still be in his first year of graduate school if he had not attended school for one or more years after receiving his undergraduate degree. The NIGMS fellowships seem to be concentrated in the second to fifth years after the baccalaureate. Combining these data with those from Table 18, which show that most traineeships and fellowships last 1-2 years, the typical pattern is to use the traineeship to support the student during his first one or two years of graduate work and then to shift him to some other form of support such as an NIGMS fellowship or perhaps a research assistantship for the remaining two or three years until he completes the PhD.

Other Sources of Support

The fact that NIGMS trainees and fellows received support from other sources is illustrated in Table 21. Of the doctorate recipients of fiscal year 1967, 819 had received NIGMS support *and* had completed the question on the Survey of Earned Doctorates questionnaire indicating sources of financial support during graduate school. The table shows, for instance, that 98 of 819 (12 percent) had received National Science Foundation (NSF) fellowship support. Half reported receiving NIH traineeships and half reported NIH fellowships (these were probably the NIGMS grants). Large percentages had teaching or research assistantships,[20] and a sizeable number used their own or their spouses' earnings. However, the NIGMS-supported group were less likely than the nonsupported group to have to use their own earnings or to be employed as research assistants, and so they were more likely to be able to devote full time to their graduate work.

IMPACT OF SUPPORT ON BIOSCIENCE STUDENTS

In fields such as biochemistry, physiology, and biophysics, the attainment of a PhD degree can be used as a meaningful measure of the contribution to professional manpower of the NIGMS programs. The main emphasis in graduate programs in these fields has been research training of predoctoral students. However, in pathology and other more clinically oriented fields in which many trainees already have MD's, the attainment of a PhD is usually not the goal, and therefore, not a good measure of the success of the training program. Success of the latter postdoctoral types of training programs could be determined using end points, such as the attainment of specialty board certification, positions in academic institutions, and/or membership in the appropriate professional organizations. Unfortunately, data on these latter criteria were not available for the study, so the following analysis is largely concerned with PhD attainment.

Time Lapse to PhD

Training grants and fellowships enabled NIGMS-supported students to attain the PhD degree in one or two years less time than did those from the same graduate departments who did not receive this support. Table 22 shows both *total time* and *registered time*[21] from baccalaureate to PhD for NIGMS-

[20] It should be noted that these formal mechanisms of support (traineeships, fellowships, and teaching and research assistantships) are provided sequentially, not concurrently, to graduate students.

[21] *Total time* refers to total calendar time elapsed between year of baccalaureate and year of doctorate; *registered time* refers to the total time registered in a university between baccalaureate and doctorate.

TABLE 21

Sources of Financial Support Reported by Bioscience Research Doctorates of Fiscal Year 1967, NIGMS Awardees Compared with Non-NIGMS Awardees

Sources of Financial Support	Bioscience Research Doctorates of FY 1967			
	With NIGMS Support		Without NIGMS Support	
	Number	Percent[a]	Number	Percent[a]
TOTAL Bioscience PhD's Reporting Support	819		1,037	
NSF FELLOWSHIP	98	12	99	10
NSF TRAINEESHIP	6	1	8	1
NIH FELLOWSHIP	412	50	93	9
NIH TRAINEESHIP	390	48	111	11
AEC FELLOWSHIP	5	1	18	2
NASA TRAINEESHIP	17	2	22	2
NDEA FELLOWSHIP	28	3	49	5
OTHER FELLOWSHIP	64	8	88	8
STATE FELLOWSHIP	14	2	26	2
INSTITUTIONAL FELLOWSHIP	68	8	113	11
WOODROW WILSON FELLOWSHIP	17	2	4	–
OTHER NATIONAL FELLOWSHIP	41	5	67	6
TEACHING ASSISTANSHIP	322	39	365	35
RESEARCH ASSISTANTSHIP	250	30	490	47
EDUCATIONAL FUND OF INDUSTRY, BUSINESS	12	2	23	2
OTHER INSTITUTIONAL FELLOWSHIP	44	5	72	7
OWN EARNINGS	104	13	230	22
SPOUSE'S EARNINGS	75	9	138	13
FAMILY CONTRIBUTIONS	33	4	40	4
LOAN	38	5	60	6
OTHER	9	1	39	4

[a] *Percentages are based on total bioscience PhD's reporting support. Percentages total more than 100% because students could indicate more than one source of financial support.*

Source: NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.
National Research Council, Office of Scientific Personnel, Docturate Records File.

supported doctorate recipients and for non-NIGMS-supported doctorate recipients. In biochemistry, for example, those who received only NIGMS traineeships required a median total time of 5.8 years to complete the PhD; those who received only NIGMS fellowships required a median 5.3 years; and those with both NIGMS traineeships and fellowships required 5.4 years. In contrast, those without NIGMS support, but from biochemistry departments that did have NIGMS training grants, required a median of 7.2 years from baccalaureate to doctorate, and those without NIGMS support and from departments without training grants required a median 8.2 years. It should be noted that the median *registered* time for these groups showed much less variation (4.6 years to 5.6 years). These data suggest that the NIGMS-supported students complete requirements for the PhD in less time than the nonsupported group because they are able to remain in school as registered students. Almost all groups in all academic fields require a median 4.5-5.5 years of registered time in a university to complete the PhD. Those who receive adequate support attain the PhD in about this time; those with less support have longer periods of nonstudent status and require more time to complete the degree requirements.

TABLE 22

Median Time Lapse from Baccalaureate to Doctorate (Total Time and Registered Time) for Fiscal Years 1958-1967 Research Doctorates with or without NIGMS Pre-PhD Traineeship or Fellowship Support, by Field of Training

Field of Training		Median Years Elapsed from Baccalaureate to Doctorate[a]					
		PhD Recipients with NIGMS Pre-PhD Support				PhD Recipients without NIGMS Pre-PhD Support	
		Total Trainees and Fellows	Trainees Only	Fellows Only	Trainee-Fellows	in Depts. with NIGMS Support	in Depts. without NIGMS Support
Total Fields	**Total Time**	**6.0**	**6.3**	**5.6**	**5.6**	b	b
	Registered	**5.2**	**5.3**	**4.8**	**5.1**		
BIOCHEMISTRY	Total Time	5.6	5.8	5.3	5.4	7.2	8.2
	Registered	5.1	5.1	4.6	5.0	5.4	5.6
PATHOLOGY	Total Time	6.5	6.5	—	—	9.1	9.6
	Registered	5.3	5.7	—	—	6.1	5.6
PHYSIOLOGY	Total Time	6.4	6.4	6.7	5.9	8.2	8.1
	Registered	5.4	5.3	5.5	5.2	5.8	5.6
MICROBIOLOGY	Total Time	6.7	6.7	6.9	5.9	8.1	8.6
	Registered	5.5	5.5	5.5	5.4	5.5	5.9
PHARMACOLOGY	Total Time	6.7	6.9	6.3	5.9	8.5	6.9
	Registered	5.4	5.3	5.2	4.9	5.4	5.1
BIOMETRICS	Total Time	7.0	6.8	—	8.3	9.4	—
	Registered	5.4	5.3	—	6.2	6.1	—
ANATOMY	Total Time	6.2	6.1	6.7	6.5	8.3	9.3
	Registered	5.3	5.2	4.8	5.3	5.4	5.8
BIOPHYSICS	Total Time	5.7	6.3	5.0	5.8	7.7	7.3
	Registered	5.1	5.4	4.5	5.3	5.7	5.7
GENETICS	Total Time	6.2	6.5	5.8	5.6	7.9	7.9
	Registered	5.3	5.4	5.0	5.0	5.2	4.9
OTHER BIOSCIENCES	Total Time	6.0	6.1	6.7	5.3	b	b
	Registered	5.2	5.1	5.4	4.8		
CHEMISTRY	Total Time	4.8	6.5	4.5	—	b	b
	Registered	4.8	5.3	4.3	—		
PHYSICAL SCIENCES & ENGINEERING	Total Time	6.4	7.2	5.7	—	b	b
	Registered	5.9	6.8	5.0	—		
HEALTH SCIENCE	Total Time	7.3	6.6	11.5	—	b	b
	Registered	5.4	—	—	—		
MEDICAL STUDENT	Total Time	9.0	9.5	—	—	b	b
	Registered	5.4	—	—	—		
OTHER FIELDS	Total Time	7.5	6.1	12.0	—	b	b
	Registered	5.4	4.9	5.8	—		

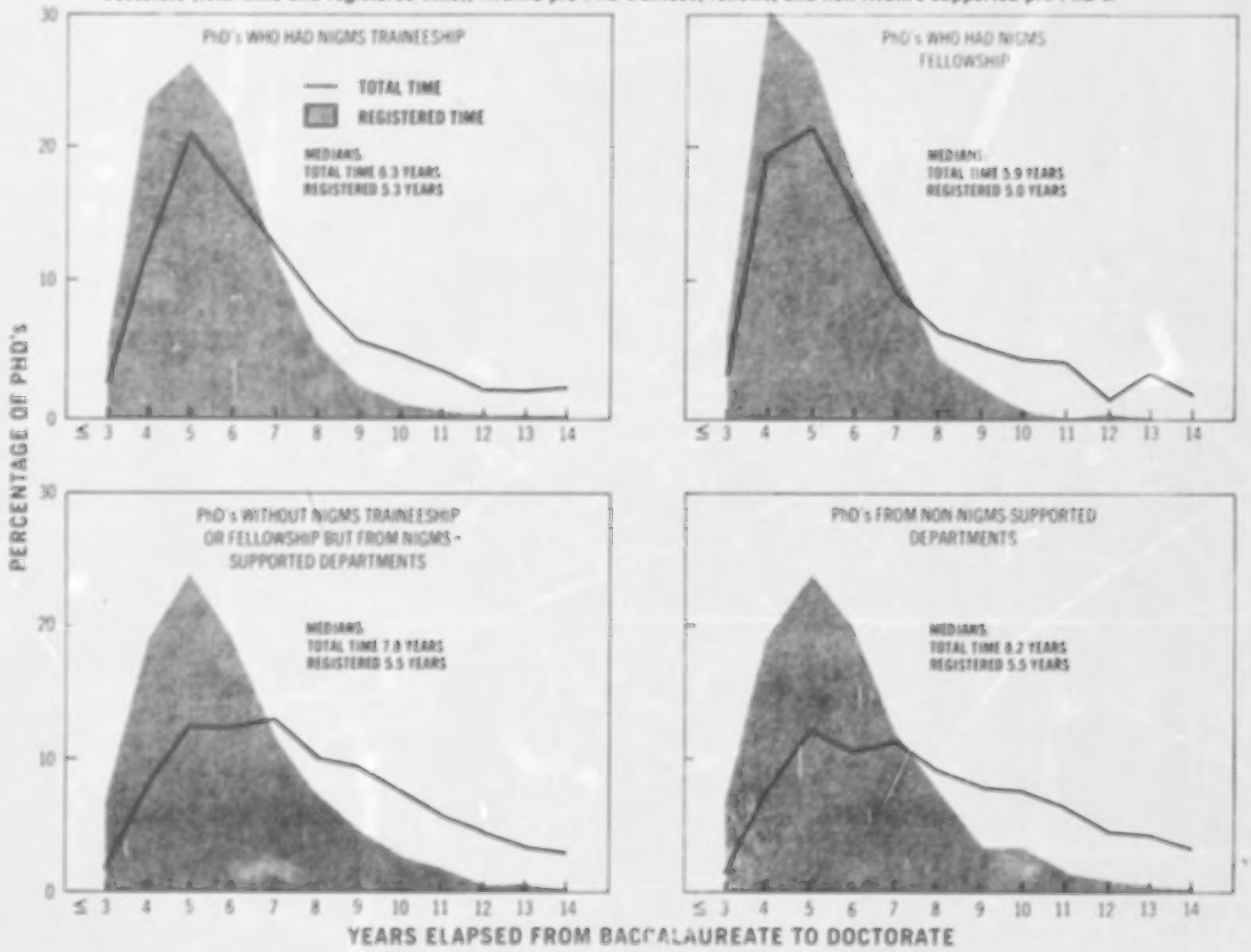
[a] *Medians were calculated only when there were 10 or more cases.*

[b] *Data for comparable fields were not available.*

Source: *National Research Council, Office of Scientific Personnel, Doctorate Records File.*
NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.

FIGURE 16

Percentage of fiscal years 1958-1967 bioscience research doctorates, by time elapsed from baccalaureate to doctorate (total time and registered time), NIGMS pre-PhD trainees, fellows, and non-NIGMS-supported pre-PhD's.



Note: Bioscience fields are the first nine shown in Table 22.

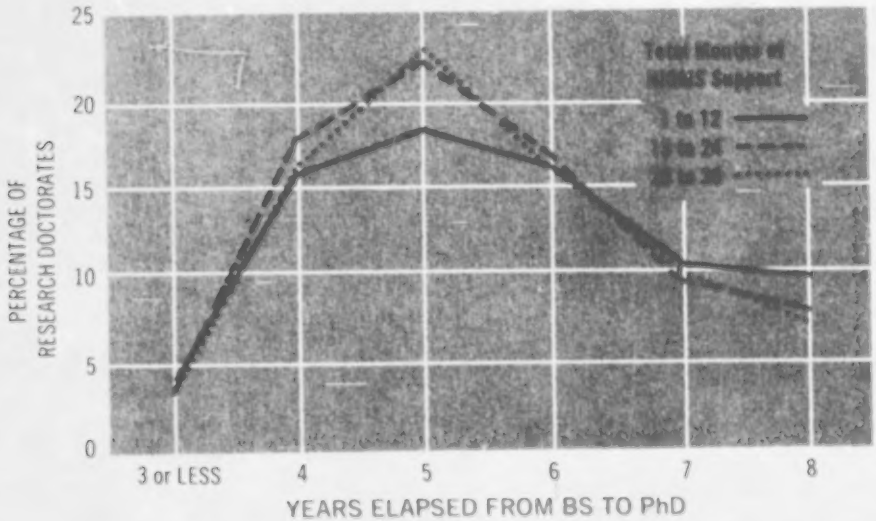
Source: NIGMS, Statement of Appointment of Trainee and Fellowship Award Statement; National Research Council, Office of Scientific Personnel, Doctorate Records File.

Figure 16 summarizes graphically the data for nine of the bioscience fields. It shows the baccalaureate-to-doctorate time-lapse distributions (total time and registered time) for NIGMS trainees, NIGMS fellows, and non-NIGMS-supported doctorate recieients.

It is clear, therefore, that the primary contribution of the training grant was that it allowed the potential bioscience graduate student to begin graduate training immediately, and it enabled him to devote full time to his academic work. The greater delay between receipt of the baccalaureate and entrance into graduate school of nonsupported students, and the resulting loss in educational momentum, was probably responsible for the fact that 82 per cent of the non-NIGMS-supported group took a master's before proceeding to the PhD as compared to 58 percent for those receiving NIGMS support.

Even though baccalaureate-to-doctorate time lapse is markedly shorter for those receiving support than for the nonsupported, the *amount* of NIGMS support *does not* correlate strongly with time lapse. That is, persons receiving two or three years of NIGMS support did not complete their PhD

FIGURE 17
Years elapsed from baccalaureate to doctorate (total time) for NIGMS pre-PhD's, by total months of NIGMS support, fiscal years 1958-1967.



TOTAL MONTHS OF SUPPORT		RESEARCH DOCTORATES BY YEARS ELAPSED FROM BS TO PhD										
		3 or Less	4	5	6	7	8	Over 8	Total Known Cases	Q_1	Q_2	Q_3
1-12	No.	46	184	212	185	118	109	304	1158	4.9	6.2	>8.5
	%	4.0	15.9	18.3	16.0	10.2	9.4	26.3	100.1			
13-24	No.	41	184	230	175	100	79	233	1042	4.7	5.9	8.2
	%	3.9	17.7	22.1	16.8	9.6	7.6	22.4	100.1			
25-36	No.	30	144	205	143	89	66	219	896	4.7	6.0	8.4
	%	3.3	16.1	22.9	16.0	9.9	7.4	24.4	100.1			

Source: NIGMS, Statement of Appointment of Trainee and Fellowship Award Statement. National Research Council, Office of Scientific Personnel, Doctorate Records File.

degrees noticeably sooner than those receiving one year of support (Figure 17).[22] This finding may reflect the fact that the NIGMS-supported students are a select group of graduate students and as such find other sources of support easily available. Trainees not in the program at the end of a year were probably not "nonsupported" but rather, obtained support from some other source. In general, comparisons of NIGMS-supported versus non-NIGMS-supported persons may well be comparisons of a rather select, generally supported group versus a less select and much less supported group.

In any case, it is evident that persons with NIGMS support, either from the training program or from a fellowship award, attained the doctoral degree in a shorter time and were less likely than other PhD recipients to depend on their own earnings, spouses' earnings, or research assistantships for financial support in graduate school. Students receiving support are able to devote themselves full time to course work and research and can finish more rapidly because other obligations are reduced.

PhD Attainment Rate

NIGMS support also seems to be positively correlated with the PhD attainment rate, defined as the percentage of beginning pre-PhD's who ultimately attain the degree. Unfortunately, comparative statistics from other studies are almost nonexistent, so the effects must be accepted with caution. This study is one of the first to follow cohorts of pre-PhD's and to determine the percentage that ultimately received the degree.

About 50 percent of those receiving training grant support ultimately attained the PhD, while 80 percent of those receiving fellowships attained the degree. Almost 85 percent of the students who had received both traineeships and fellowships ultimately received the PhD (Figure 18).[23] It is likely that the superior performance of the trainee-fellow group was influenced by the selection of trainees who had already demonstrated one to two years of satisfactory or superior performance in graduate school for predoctoral fellowships. The largest attrition in graduate training occurs during the first two years, and most NIGMS fellowships are awarded in the third and fourth years (Figure 15). Traineeships, which are awarded in the first and second years, support the less tested and selected group, and this probably accounts for their lower PhD attainment rate.

These PhD attainment rates of NIGMS trainees and fellows compare favorably with those available from the few comparable studies that have been reported. For example, studies conducted by the American Institute of Physics[24] show that of 3,800 beginning graduate students in physics in 1962-1963, only about 1,100 received PhD's in 1966-1967. This corresponds roughly to an attainment rate of 30 percent.

A follow-up study of doctorate attainment was conducted in the Office of Scientific Personnel as part of research on fellowship selection of National Science Foundation fellows.[25] It showed that of all NSF bioscience applicants who were first-year graduate students in 1955 and 1956, 76 percent of the

[22]The difference in baccalaureate-to-doctorate time lapse for those receiving less than 12 months of support versus that for those receiving more than 12 months of support does show some statistically significant variation, but differences in median time lapse (6.2 versus 6.0) are of little practical significance.

[23]The bars in Figure 18 do not indicate cumulative percentages. They show the percentage of each of 10 cohorts who had received PhD's by fiscal year 1967. One such cohort was the group of "trainees only" who had had their baccalaureates for at least 10 years, another was the group of students who had had their baccalaureates for 9 years, etc.

[24]*Physics Education, Employment, and Financial Support* (American Institute of Physics, New York, 1964), Publication No. R-161.

[25]*Some Characteristics of First-year and Intermediate Fellowship Applicants Eight to Ten Years Later*, Technical Report No. 24 (National Academy of Sciences, Washington, D.C., 1965), p. 15.

FIGURE 18
Percentage of NIGMS pre-PhD trainees and fellows attaining the PhD, by years since the baccalaureate.

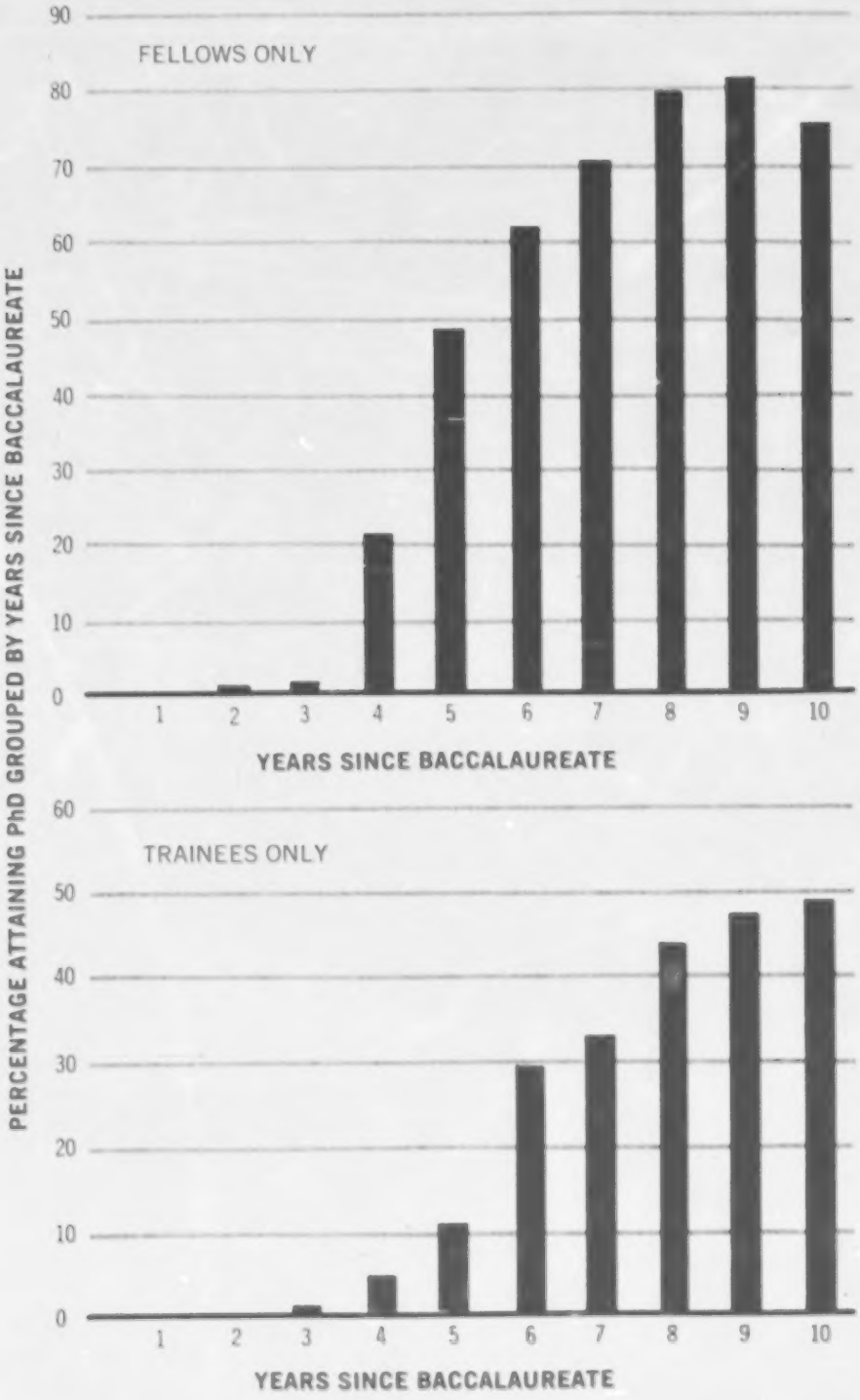
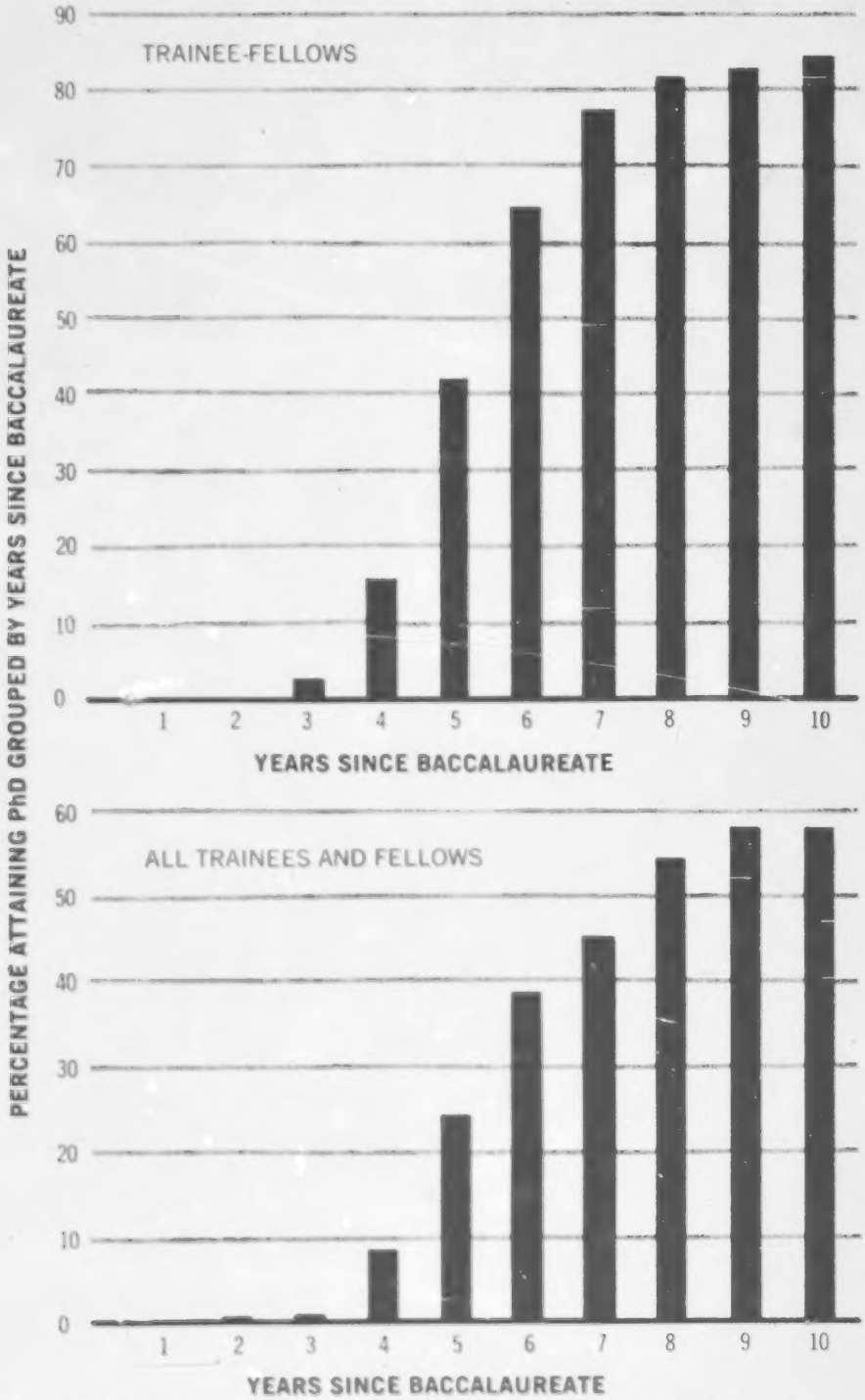


FIGURE 18 (continued)



Source: NIGMS, Statement of Appointment of Trainee and Fellowship Award Statement. National Research Council, Office of Scientific Personnel, Doctorate Records file.

TABLE 23
Characteristics of NIGMS-Supported Pre-PhD's Who Did and Who Did Not Attain the PhD as of Fiscal Year 1967[a]

Characteristics of Pre-PhD's	Period of First NIGMS Support							
	FY 1958-1960		FY 1961-1962		FY 1963-1964		FY 1965-1967	
	Attained PhD by FY 1967	No PhD by FY 1967	Attained PhD by FY 1967	No PhD by FY 1967	Attained PhD by FY 1967	No PhD by FY 1967	Attained PhD by FY 1967	No PhD by FY 1967
TOTAL Number	553	440	1,463	1,136	1,534	2,240	606	6,147
Trainee Only	418	419	914	990	737	1,859	262	5,055
Fellow Only	13	6	240	66	584	184	298	889
Trainee-Fellow	122	15	309	80	213	197	46	203
PERCENTAGE OF MALES	63	37	63	37	47	53	10	90
PERCENTAGE OF FEMALES	37	63	38	62	23	77	6	94
PERCENTAGE OF U.S. CITIZENS	56	44	56	44	41	59	9	91
PERCENTAGE OF FOREIGN CITIZENS	55	45	60	40	40	60	11	89
MEDIAN AGE AT FIRST AWARD	27	25	27	25	27	25	28	25
MEDIAN TOTAL MONTHS OF NIGMS SUPPORT	31	13	29	14	25	20	13	12
MEDIAN TOTAL STIPEND AND DEPENDENCY ALLOWANCE	$7,600	$2,330	$7,550	$3,110	$7,120	$4,470	$4,560	$2,920

[a]*The decrease in percentage of persons attaining the PhD, of median months of support, and of median stipend and dependency support results simply from the fact that those who have received support in more recent years have had less opportunity to attain the degree or to have been supported than those from earlier years.*

Source: NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.
National Research Council, Office of Scientific Personnel, Doctorate Records File.

fellowship awardees had received PhD's ten years later, and only 34 percent of the nonawardees had received PhD's by that time. For NSF fellowship applicants who were in the second or later year of graduate work in 1955 and 1956, the percentages were 89 percent for the awardees and 70 percent for the nonawardees. The over-all total for the bioscience applicants, summing awardees and nonawardees and all graduate levels, was 60 percent. The performance of NIGMS trainees and fellows compares very favorably with the highly selective NSF fellowship program.

A follow-up study of National Defense Education Act (NDEA) fellowship recipients was carried out for the U.S. Office of Education by the Bureau of Social Science Research, Inc.[26] Matching the records of 5,529 NDEA fellows for the period 1960-1963 against the Doctorate Records File showed that 2,497 (45 percent) had attained research doctorates by fiscal year 1968.

FACTORS RELATED TO DOCTORATE ATTAINMENT

A comparison of characteristics of NIGMS-supported pre-PhD's who did and who did not attain the doctorate by fiscal year 1967 is presented in Table 23. Men are more likely to complete the PhD than women. There is no significant difference between the percentage of U.S. citizens and the percentage of foreign nationals attaining the PhD. A greater percentage of those with fellowship support than those in the "traineeship only" category completed the degree, reflecting the fact that fellows are selected from students who are well along in graduate work. Perhaps the most striking statistic in the table is the difference between the two groups in amount of support. The PhD recipients received markedly more support (in months and dollars) than did the non-PhD's. It appears, therefore, that while the total amount of NIGMS support does not correlate strongly with time lapse to PhD, it does correlate with ultimate attainment of the degree.

Field Switching

Students in most academic specialties experience a certain amount of shifting in career choice in the course of graduate work, and bioscience students are no exception. Table 24 shows the shifting of NIGMS-supported pre-PhD students from baccalaureate to training field to doctoral field. For example, of 899 persons who received NIGMS support for training in biochemistry, 185 (20 percent) had obtained baccalaureates in one of the biosciences, 589 (66 percent) had obtained their baccalaureates in chemistry, and the remaining 125 (13 percent) had obtained their baccalaureates in some other field. After training, 732 of the 899 (81 percent) obtained their research doctorates in biochemistry and 167 (19 percent) obtained their research doctorates in some other field. In some universities, graduate education in biochemistry is given in departments of chemistry, and degrees are awarded in this discipline.

The shifts between baccalaureate and training field are somewhat difficult to interpret because many training fields do not exist as baccalaureate majors. It is of interest to note, however, that only 40 percent of the bioscience trainees and fellows were baccalaureates in any of the biosciences. Chemistry majors and other science majors constitute most of the input to the NIGMS research-oriented training programs.

Comparison of initial training field and PhD field shows that 66 percent of the trainees and fellows received doctorates in the same academic field as that of training.

Post-Training Careers

The ultimate impact of the training program is its effect on the professional capabilities of bioscience research manpower. After training, what kinds of professional careers do NIGMS-supported students pursue? For whom do they work? What is their major work activity? Do they do productive research? This final section presents data showing type of employer and type

[26]Bureau of Social Science Research, Inc. *Study of NDEA Title IV Fellowship Program, Phase I* (Washington, D.C., 1968).

TABLE 24
Field-Switching of Pre-PhD NGMS Trainees and Fellows Who Attained the Doctorate, Baccalaureate Major–NIGMS Training Area–Research Doctorate Major

Baccalaureate Major[a]	Number	Percent	NIGMS Training Area	Number (100%)	Research Doctorate Major	Number	Percent
Biosciences	1,700	40	TOTAL All Fields	4,246	Same as training area	2,792	66
Chemistry	1,294	30			Other	1,454	34
Other	1,252	30					
Biosciences	185	20	BIOCHEMISTRY	899	Biochemistry	732	81
Chemistry	589	66			Other	167	19
Other	125	13					
Biosciences	12	46	PATHOLOGY	26	Pathology	9	35
Chemistry	6	23			Other	17	65
Other	8	31					
Biosciences	264	63	PHYSIOLOGY	419	Physiology	275	66
Chemistry	32	8			Other	144	34
Other	123	29					
Biosciences	325	74	MICROBIOLOGY	442	Microbiology	341	77
Chemistry	46	10			Other	101	23
Other	71	16					
Biosciences	74	30	PHARMACOLOGY	248	Pharmacology	217	88
Chemistry	57	23			Other	31	12
Other	117	47					
Biosciences	18	10	BIOMETRICS	176	Biometrics	66	38
Chemistry	4	2			Other	110	62
Other	154	88					
Biosciences	149	74	ANATOMY	201	Anatomy	145	72
Chemistry	11	6			Other	56	28
Other	41	20					
Biosciences	85	25	BIOPHYSICS	336	Biophysics	115	34
Chemistry	111	33			Other	221	66
Other	140	42					

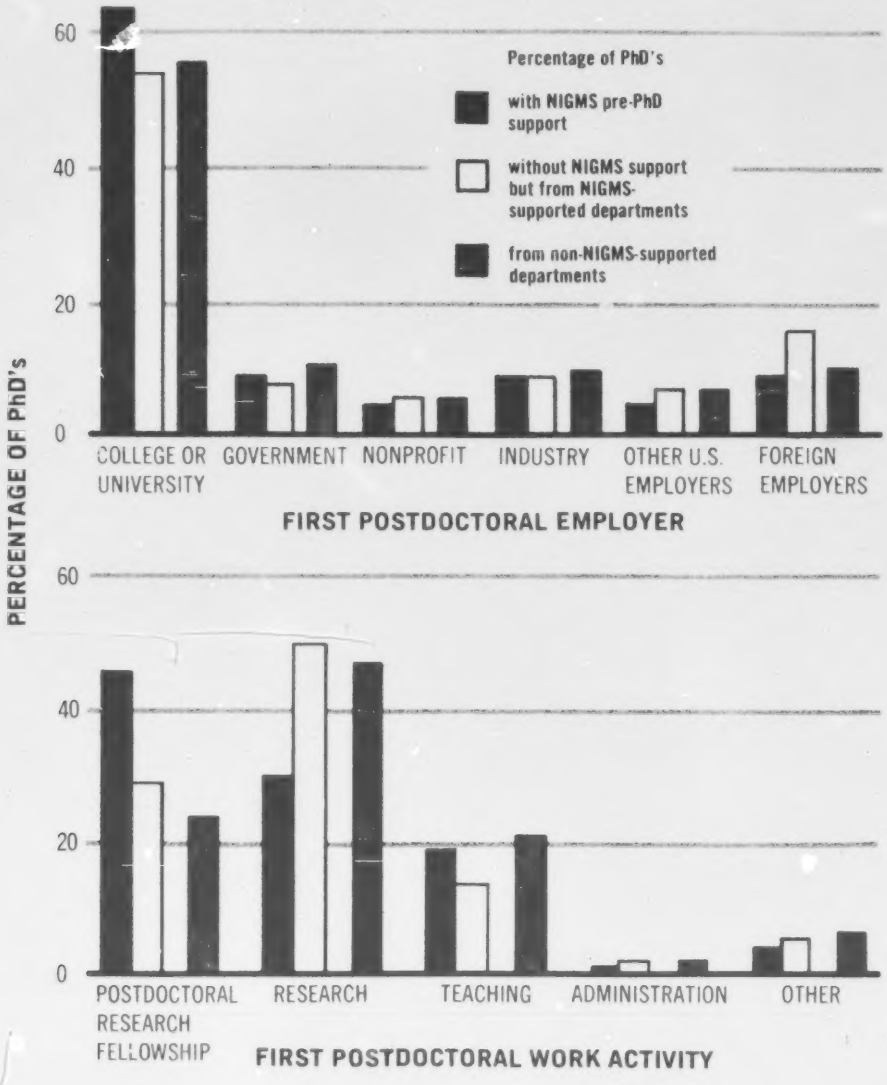
TABLE 24 (Continued)

Baccalaureate Major[a]	Number	Percent	NIGMS Training Area	Number (100%)	Research Doctorate Major	Number	Percent
Biosciences	206	72	GENETICS	288	Genetics	144	50
Chemistry	21	7			Other	144	50
Other	61	21					
Biosciences	324	72	OTHER BIOSCIENCES	447	Other Biosciences	253	57
Chemistry	46	10			Other	194	43
Other	77	17					
Biosciences	—	—	CHEMISTRY	380	Chemistry	369	97
Chemistry	325	86			Other	11	3
Other	55	14					
Biosciences	—	—	PHYSICAL SCIENCES		Physical Sciences and Engineering	29	83
Chemistry	1	3	AND ENGINEERING	35	Other	6	17
Other	34	97					
Biosciences	25	18	HEALTH SCIENCES	137	Health Sciences	6	4
Chemistry	35	26			Other	131	96
Other	77	56					
Biosciences	7	37	MEDICAL STUDENTS	19	Other	19	100
Chemistry	2	10					
Other	10	53					
Biosciences	26	14	ALL OTHER FIELDS	187	Same as training area	91	49
Chemistry	8	4			Other	96	51
Other	153	82					
Biosciences	—	—	UNKNOWN	6	Other	6	100
Chemistry	—	—					
Other	6	100					

[a] *"Biosciences" includes the first 10 fields listed for NIGMS training areas. "Other" includes cytology, embryology, botany, phytopathology, ecology, entomology, hydrobiology, zoology, and general bioscience.*

Source: NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.
National Research Council, Office of Scientific Personnel, Doctorate Records File.

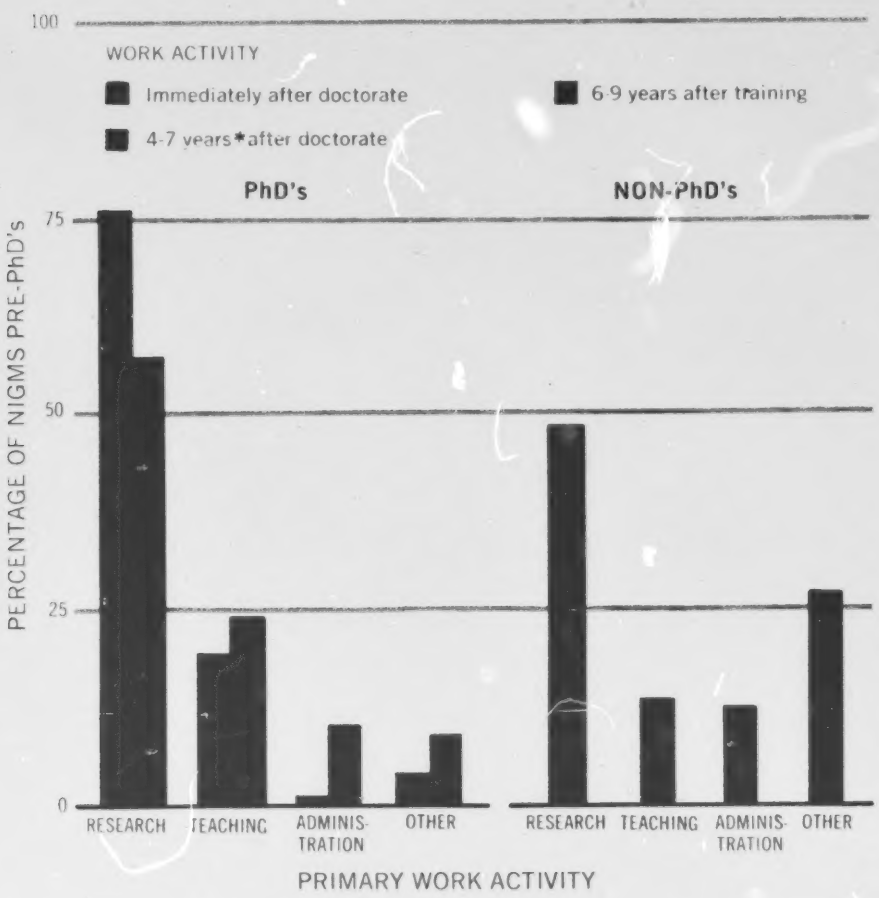
FIGURE 19
First postdoctoral employer and primary work activity of fiscal year 1962-1967 bioscience research doctorates who had or had not received NIGMS pre-PhD support.



Source: National Research Council, Office of Scientific Personnel, Doctorate Records File. NIGMS, Statement of Appointment of Trainee and Fellowship Award Statement.

of work activity for PhD recipients with NIGMS support and without support, and it supplies data about the post-training careers of trainees who did not attain the PhD. These data are based on a follow-up letter that was mailed to 800 pre-PhD trainees who had received their first NIGMS appointment in the period 1958-1960, supplemented by data from the National Register of Scientific and Technical Personnel for trainees of the period 1961-1962. Of the 800 letters mailed, replies were received from 595

FIGURE 20
Primary work activity of NIGMS pre-PhD trainees immediately after receiving a research doctorate and 4 to 7 years later; and for those without a research doctorate, 6 to 9 years after training.



*Seventy percent of the NIGMS pre-PhD trainees who obtained a PhD were awarded the degree between 1961 and 1964. Therefore, their reported work activity in 1968 was about 4 to 7 years after obtaining their degree.

Source: NIGMS, Statement of Appointment of Trainee.
National Research Council, Office of Scientific Personnel, 1968 Follow-Up Study of 1958-60 NIGMS pre-PhD's, and Doctorate Records File.
National Science Foundation, 1966 National Register of Scientific and Technical Personnel.

persons (74 percent); 480 of the 595 had attained research doctorates by fiscal year 1967. Information about an additional 327 trainees of the period 1961-1962 who had not attained the PhD by fiscal year 1967 was obtained from the National Register. Types of postdoctoral employers and types of postdoctoral work activities for these 922 former trainees are described in Figures 19 and 20 and in Table 25.

Figure 19 indicates immediate postdoctoral employers and immediate postdoctoral work activities for three groups of bioscience doctorate recipients: (1) those who had received NIGMS trainee or fellowship support; (2) those who had not received NIGMS support but had obtained their doctorates from departments with NIGMS training grant programs; and (3) those without NIGMS support and from departments that did not have

NIGMS training grant programs. The three groups showed little variation in types of first postdoctoral employers, but they did show large differences in types of first postdoctoral work activities.

Those doctorate recipients with NIGMS support were more likely than nonsupported PhD's to obtain immediate postdoctoral fellowships. The greater percentage of the non-NIGMS-supported doctorate recipients became employed full-time, with research as their major work activity. The preselection of the more qualified students for traineeships and fellowships continues to be reflected in their subsequent ability to compete successfully for postdoctoral fellowships. Students who have not had this support are probably older than those in the supported group, since achievement of the degree takes more time for them, and they may therefore find it expedient to enter more permanent positions immediately.

Figure 20 compares the immediate postdoctoral work activity of NIGMS-supported pre-PhD trainees with their work activity four to seven years after receipt of the doctorate. It is apparent from these data and from similar studies that other functions compete with research more and more strongly as the person gains work experience. Of the doctorate recipients who were in their first postdoctoral year, 24 percent were engaged in

TABLE 25

Employer and Primary Work Activity in 1966-1968 of NIGMS Pre-PhD Trainees Who Did or Did Not Receive Research Doctorates

Percentage of NIGMS Pre-PhD Trainees Who Received the PhD			
By Employer in 1966-1968		By Work Activity in 1966-1968	
TOTAL	100	TOTAL	100
COLLEGE OR UNIVERSITY	43	Research	57
HOSPITAL	29	Teaching	24
GOVERNMENT	5	Administration	10
NONPROFIT ORGANIZATION	4	Professional Services	6
INDUSTRY OR BUSINESS	11	Other	3
OTHER	8		

Percentage of NIGMS Pre-PhD Trainees Who Did Not Receive the PhD			
By Employer in 1966-1968		By Work Activity in 1966-1968	
TOTAL	100	TOTAL	100
COLLEGE OR UNIVERSITY	22	Research	48
HOSPITAL	23	Teaching	13
GOVERNMENT	20	Administration	12
NONPROFIT ORGANIZATION	4	Professional Services	20
INDUSTRY OR BUSINESS	19	Other	7
OTHER	12		

Source: *NIGMS, Statement of Appointment of Trainee.*
National Research Council, Office of Scientific Personnel, 1968 Follow-Up Study of 1958-1960 NIGMS Pre-PhD's, and Doctorate Records File.
National Science Foundation, 1966 National Register of Scientific and Technical Personnel.

TABLE 26

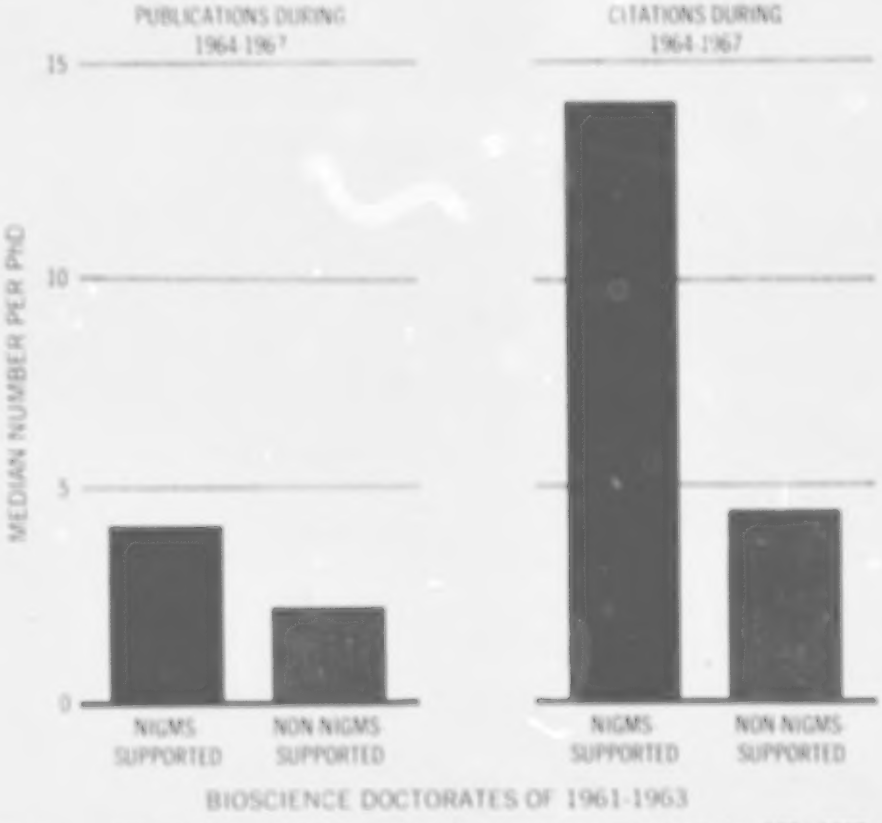
Median Number of Publications (Authored or Coauthored) and Citations (Excluding Self-Citations) Appearing 1964-1967 for Baccalaureate Research Doctorates of 1961-1963, by Field, With or Without NIGMS Support

Field of Doctorate	Total PhD's in Sample: with NIGMS Support Number	Percent	without NIGMS Support[a] Number	Percent	Median Number of Publications 1964-1967 per PhD: NIGMS-Supported PhD's	Non-NIGMS-supported PhD's[a]	Percentage of PhD's with Zero Publications: NIGMS-Supported	Non-NIGMS-Supported[a]	Median Number of Citations 1964-1967 Per PhD: NIGMS-Supported PhD's	Non-NIGMS-Supported PhD's[a]	Percentage of PhD's with Zero Citations: NIGMS-Supported	Non-NIGMS-Supported[a]
TOTAL	268	100	502	100	4.0	2.3	13	22	14.1	4.4	12	20
BIOCHEMISTRY	72	27	116	16	3.6	2.8	8	26	17.1	9.7	4	18
PATHOLOGY	2	1	11	2	—	1.0	—	36	—	4.3	—	9
MICROBIOLOGY	33	12	123	18	3.6	1.6	15	33	19.2	5.6	6	21
PHYSIOLOGY	18	7	39	5	3.5	3.2	17	13	6.5	6.0	6	18
PHARMACOLOGY	28	10	25	4	7.5	4.0	—	24	26.9	7.0	21	12
BIOMETRICS	23	9	3	—	3.2	—	9	—	2.0	—	22	—
ANATOMY	22	8	17	2	6.5	4.8	18	6	20.5	8.8	14	18
BIOPHYSICS	6	3	14	2	—	3.5	—	7	—	18.0	13	7
GENETICS	24	9	40	6	2.2	1.5	30	28	8.8	3.7	25	15
OTHER BIOSCIENCES	38	14	115	45	2.9	1.6	18	34	9.5	3.3	16	22

[a] PhD's who did not receive NIGMS support but were PhD's in NIGMS-supported departments.

Source: Institute for Scientific Information, Science Index, and Citation Index, 1964-1967.
NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.
National Research Council, Office of Scientific Personnel, Doctorate Records File.

FIGURE 21
Median number of publications and citations appearing 1964-1967 per bioscience research doctorate of 1961-1963, with and without NIGMS pre-PhD support.



Source: Institute for Scientific Information, Source Index and Citation Index, 1964-1967.
NIGMS, Statement of Appointment of Trainee and Fellowship Award Statement.
National Research Council, Office of Scientific Personnel, Doctorate Records File.

noninvestigative activities. This percentage grew to 43 percent for those with four to seven years of postdoctoral experience. Administration was reported by only 1 percent of the first group, but by 10 percent of the latter group; teaching increased from 19 percent to 24 percent.

Although the proportion of those engaged in research (including postdoctoral fellowship research) dropped from 76 percent to 57 percent, in general, the former trainees appear to be more research-oriented than their colleagues. When compared with all bioscience PhD's in the National Register of Scientific and Technical Personnel, 57 percent listed research as their primary work activity, as compared to 46 percent for the Register bioscience PhD's, 24 percent listed teaching (29 percent in the Register), and 10 percent listed administration (17 percent in the Register). It must be remembered, however, that faculty members who list research as their major function contribute substantially to the teaching programs in their institutions.

Figure 20 and Table 25 also compare the work activities of trainees who had received PhD's with those who had not received PhD's by fiscal

year 1967. The data show that 45 percent of the non-PhD's had found employment in a university or hospital, and so were contributing to education and health-related activities. The effect of the traineeship is reflected also in the fact that 48 percent reported research as their primary work activity.

Table 26 and Figure 21 compare the publication and citation counts for NIGMS-supported bioscientists with counts of nonsupported bioscientists who received PhD's from NIGMS-supported departments. Both groups were PhD recipients during the period 1961-1963, and the publication and citation counts are for the period 1964-1967. Therefore, the two groups have been matched for time of receipt of PhD, type of graduate department, and period of publication; however, the proportion of bioscientists within each subfield was not matched. The results are tabulated by PhD field.

The median number of publications (1964-1967) for the former NIGMS trainees was 4.0 compared with 2.1 for the non-NIGMS group. Only 13 percent of the NIGMS group had no publications during this four-year period, compared with 22 percent for the non-NIGMS group. The differences in citation rates are even more striking. Former trainees have a median of 14.1 citations to their works (1964-1967) as compared with 4.4 for the non-NIGMS group. These data indicate that the NIGMS trainees who attained PhD's were generally more productive in their research than PhD's from matched fields and departments who had not been NIGMS trainees.

SUMMARY

- After a period of initial growth, the numbers of NIGMS-supported trainees and fellows leveled off in 1965 at approximately 7,700 and 1,100 per year, respectively.
- In the period 1958-1967, a total of 28,503 persons received NIGMS training support. Of these, 23,380 were "trainees only"; 3,759 were "fellows only"; and 1,364 received both traineeship and fellowship support.
- The typical pattern of support was to use traineeship funds to support the student during his first one or two years of graduate work and then shift him to some other form of support, such as an NIGMS fellowship or perhaps a research assistantship for the remaining two or three years until he completed the PhD.
- During the course of their graduate study, the NIGMS-supported students did receive support from other sources, but they were much less likely to be dependent on their own earnings or research assistantships than non-NIGMS-supported bioscience graduate students.
- The baccalaureate-to-PhD time lapse for NIGMS trainees and fellows was one to two years less than for non-NIGMS-supported doctorate recipients in matched fields and from matched graduate departments.
- The PhD attainment rate for NIGMS-supported students compared favorably with that reported in the few similar studies available. About 50 percent of the pre-PhD "trainees only" ultimately attained the PhD; 80 percent of the "fellows only" attained the degree; and 85 percent of the "trainee-fellows" received PhD's. This compared with a 76 percent attainment rate for all NSF bioscience fellowship awardees who were first-year graduate students in 1955 and 1956 and a 45 percent attainment rate for NDEA fellowship recipients of the period 1960-1963.
- The NIGMS training program drew heavily for student input from baccalaureate majors in chemistry and other nonbiological sciences. However, most trainees (59 percent) who received PhD's indicated their PhD field to be the same as the training field.

- A larger proportion of doctorate recipients with NIGMS support assumed immediate postdoctoral research fellowships than did those without this support.

- As the doctorate-recipient group gains professional maturity, it performs more diversified functions. By 4-7 years after the doctorate, the proportion of former NIGMS trainees engaged primarily in research (including postdoctoral fellowship research) dropped from 76 percent to 57 percent. The percentage in administration and in teaching increased.

- Forty-five percent of the trainees who did not attain the PhD found employment in universities or hospitals and were engaged in health-related activities. The training programs are therefore contributing skilled persons to the biomedical manpower pool in addition to those who attain the doctoral degree.

- Doctorate recipients supported previously by NIGMS training grants produced on an average more publications of higher quality (as judged by number of citations to their work in the literature) than those without NIGMS support and from matched graduate departments.

CHAPTER V

RECOMMENDATIONS

CONTINUATION
LEVEL OF SUPPORT
PATTERNS OF SUPPORT AND ADMINISTRATION
CONTINUED EVALUATION

The Advisory Committee of eight bioscientists met frequently during the course of the study to review the data and suggest additional questions that needed more thorough investigation. The resulting tabulations were many times as detailed and voluminous as those presented in this report. After studying all the information that had been collected, the committee held two final meetings—a four-day meeting in July 1968 and a two-day meeting in December 1968—devoted to the difficult task of interpreting and evaluating the data. The following recommendations summarize the committee's judgments of the implications of the study to NIGMS. The recommendations have been grouped into four major categories.

CONTINUATION

Recommendation: Although the rapidly changing character of graduate education hampered evaluation of the effects of the Graduate Research Training Grant Program on total bioscience PhD production, the program did have measurable positive impacts on the departments and on the students. The program, therefore, should be continued.

The goals of the training grant program, as stated in the introductory chapter of this report, are being achieved.

1. The program has had a positive impact on the training departments:

a. Graduate student enrollments and PhD production of departments with grants increased at a faster rate than did those of departments without grants. In biochemistry, for instance, the number of full-time students in departments with NIGMS support doubled between 1960 and 1965, but enrollments in departments without support went up only 50 percent. When matched for PhD output before 1958, the PhD production of departments with NIGMS support increased about twice as fast between 1958 and 1967 as corresponding outputs in departments without support. Even though other factors also contributed to these differential growth rates, the training grant program appears to affect PhD output positively. The exact amount of the effect cannot be determined from the data.

b. The departments added new equipment, which expanded their research training capacities.

c. Departments were able to add new faculty and strengthen their programs.

d. Training grants facilitated the development of new PhD-granting departments and interdepartmental programs.

e. In applying for training grants, departments were required to make careful evaluations of current graduate programs, and this critical re-examination frequently resulted in program revision.

2. The program has had a positive impact on the training of students:

a. The PhD attainment rate of students receiving NIGMS support was high. About 50 percent of the NIGMS pre-PhD trainees and over 80 percent of the NIGMS pre-PhD fellows attained the degree. These attainment rates compare favorably with those reported in the few similar studies available from other programs.

b. The baccalaureate-to-doctorate time lapse for students with training grant support is less than that for students in the same departments, but without NIGMS support, by one or two years.

c. Almost 50 percent of the bioscience doctorate recipients who had received NIGMS training support were awarded immediate postdoctoral research fellowships, while only 29 percent of doctorate recipients from the same departments, but without NIGMS support, were awarded postdoctoral research fellowships.

d. Doctorate recipients supported by NIGMS grants produced, on the average, twice as many publications as nonsupported PhD's from the same departments, and their publications were cited three times as often by others, suggesting research of higher quality.

LEVEL OF SUPPORT

Recommendation: The number of students supported annually by the NIGMS training grants should be determined by the national need for high-level bioscience manpower. Until wide-ranging studies of societal need for such manpower for research, teaching, and administration can be completed, it is recommended that the results of recent studies be accepted to establish temporary manpower goals. These available studies suggest that the number of bioscience doctorates should be increased—perhaps doubled—to meet future requirements.

1. The projection of manpower requirements is an uncertain process dependent on the nature of the assumptions made. Data cited in the introductory chapter indicate that the projected supply of bioscientists with research doctorates is markedly less than the projected demand. These scientists will be needed to perform research, staff medical schools, and teach in the biosciences in colleges and universities.

2. An adequate baccalaureate pool exists—adequate in numbers and quality—for an expansion of doctoral output. Comparison of the number of bioscience PhD's with numbers of bioscience baccalaureates shows a ratio of roughly 1 PhD to 12 baccalaureates. This ratio is about 1 to 6 for the physical sciences. The Academic Performance Index of bioscience baccalaureates compares favorably with those of baccalaureates from other disciplines. Therefore, a doubling of the ratio of PhD's to baccalaureates in the biosciences should be possible without a lowering of the quality of output.

Recommendation: The stipend level for pre-PhD NIGMS trainees should be increased. An initial step increment of 25 percent should be made, and, thereafter, stipends should be related to the cost-of-living index.

1. The NIGMS stipend for a pre-PhD trainee ($2,400-$2,800 per 12 months), even when supplemented by a dependency allowance of $500 per 12 months per dependent, is about half the average yearly expenses of a bioscience graduate student. In recognition of this fact, present government policy allows universities to "supplement" student stipends from non-Federal funds in an amount not to exceed $1,000 per 12-month period.* The recommended 25 percent increment would bring the annual stipend level to $3,000-$3,500 and would remove the need for the university supplement.

2. If the above recommendations (increasing both the number of trainees supported and the stipend per trainee) were put into effect, a large increase in training grant funds would be required. In addition, however, it should be recognized that increased support for traineeships, while necessary, is not sufficient. Research training implies the existence of active research programs and research facilities in the departments involved. Therefore, increasing the number of trainees requires also increased support for research and research facilities. It is recommended that NIGMS training grant support be coordinated with planning for research and facilities support by NIH.

3. The committee recommends also that a separate study be made with regard to the adequacy of NIGMS postdoctoral stipends.

Recommendation: A cost-of-education allowance equal at least in amount to the stipend allowance should be provided by NIGMS to be used in improving the research training capability of the department.

Data indicate that the cost-of-education portion of the total training program support has been decreasing in recent years. In 1966, cost-of-education support amounted to $23.2 million, or 53 percent of the total training program support. By 1968, this amount decreased to $21.1 million, or 47 percent of the total. The committee recommends that this support not drop below 50 percent because of the importance of these funds to departments in maintaining training capability and quality.

PATTERNS OF SUPPORT AND ADMINISTRATION

Recommendation: The present NIGMS policy of utilizing peer judgment by competent bioscientists in the selection of review and advisory committees should be continued. However, a broader representation of the bioscience professional community should be sought in such consultation.

The committee proposes that a systematic procedure be developed that would allow department chairmen, professional society personnel, and other groups to cooperate with NIGMS in devising lists of potential committee members. Review and advisory committee members should be selected by broad sampling from these lists.

Recommendation: It should be possible to move students on and off training grants as local conditions demand. Any student who has been supported *at any time* by the training grant should be credited to the training grant program when the effectiveness of the program is being evaluated.

1. The data show that most trainees received training grant support for one or two years, typically during the first two years of graduate work. The remaining two or three years of work were generally supported from other sources, including fellowships and research assistantships. In contrast to this actual practice, recent NIGMS policy has required trainee appointments to be for the full period of graduate training. The committee recommends that the NIGMS policy be made more flexible by permitting the department to utilize the various methods of graduate student support at its disposal as seems most helpful for the graduate student.

2. In evaluating the effectiveness of graduate student support programs, the PhD recipient is often credited to the source of support during his final year of graduate study. This process seriously underestimates the

*As of June 14, 1968, policy changes in NIH removed the $1000 limit from non-Federal supplementation. Under special circumstances, supplementation up to $1000 per annum from Federal, but not NIH, funds may be permitted.

contribution of the NIGMS training program, which has supported many students during the initial stages of graduate training but not during the final year of study for the doctorate. Therefore, it is recommended that all students supported by NIGMS traineeships at any time in their graduate work be counted as recipients of NIGMS aid.

Recommendation: Present NIGMS policies, which (1) emphasize predoctoral training, (2) attempt to balance support between on-going programs and new programs in departments where quality can be developed, and (3) continue departmental support for new programs for a minimum of five years, are useful and should be continued.

1. For those nonclinical disciplines where attainment of the PhD is the normal goal of the training program, primary emphasis should continue to be placed on supporting the predoctoral programs. Other sources of support, such as research grants, would be generally more appropriate for postdoctoral students.

2. The quality and productivity of on-going programs and newly established programs should continue to be assessed periodically.

3. The data show that the time lapse from graduate school entry to the PhD for pre-PhD trainees is between five and six years, so support for training programs at institutions should ordinarily continue for a minimum of five years.

CONTINUED EVALUATION

Recommendation: The NIGMS Graduate Research Training Grant Program should have among its goals that of providing an opportunity for the educationally and culturally disadvantaged to pursue careers in biomedical research. It should be recognized that such students may require more support than currently enrolled students. Such programs should be evaluated carefully to see that they have attained their stated objectives, making allowances for the beginning level of the students.

Recommendation: Periodic evaluation of the NIGMS training program is desirable. Future evaluation would require the continued collection of data describing the various aspects of the program, including quality aspects, as objectively as possible. However, there will continue to be a need for expert subjective evaluation of these programs.

1. The present study is based on a large number of objective data that describe many aspects of the NIGMS training program during the past decade. These descriptive statistics are essential for evaluation and for administrative uses. They should continue to be gathered. The data file will become increasingly valuable with time.

2. Evaluation of the NIGMS program—as opposed to its description—presents many difficulties, which have been discussed in this report. Future studies will continue to need expert subjective judgments provided by people with broad experience in the areas being surveyed.

3. In addition to the rather general evaluative problems noted above, some very specific ones appeared during the study:

- Information about the contribution to training of other NIH institutes was available in part (introductory chapter) but not in sufficient detail. Future studies would be more meaningful if all NIH institutes with training programs participated.
- Comparative statistics (NIGMS versus non-NIGMS) were frequently not available. The committee suggests that NIGMS support the collection of relevant data from departments without training grant programs in order to provide comparative data.

- Some greater degree of coordination should be instituted so that NIGMS data collection and coding will be maximally compatible with that from other data sources. For instance, specialties lists from the National Institutes of Health, the National Science Foundation, the U.S. Office of Education, and the National Academy of Sciences describing academic fields differ widely, introducing the possibility of error when these data sources are merged.
- Certain potentially valuable data sent to NIGMS from the NIGMS-supported departments are not in readily retrievable form. For example, the expenditure reports contain very useful information, but the data are not in machine-retrievable form and so are not readily available for analysis. The committee suggests that procedures for collecting and storing data be modified to make data more usable.
- Merging of all NIGMS traineeship and fellowship records for a given individual would be greatly facilitated if each record contained the person's Social Security Number.

APPENDIX A

History of Federal Government Support for Research and Training in the Biomedical Sciences

An expanding research-and-development program requires an increase in the number of scientists prepared to carry out the investigations involved. This was clearly recognized during World War I and, at that time, the National Academy of Sciences was called on to mobilize the nation's scientific personnel and capabilities to the support of the war effort. The National Research Council (NRC) was created by the Academy to organize research-and-development projects essential to the conduct of the war and to locate and secure the scientific personnel and facilities needed to implement these projects. After the war, the government asked the NRC to continue its activities with the purpose of "increasing knowledge, strengthening the national defense, and contributing in other ways to the public welfare."

Meanwhile, the scope and responsibilities of the Public Health Service, reorganized in 1912, were broadened by Congress to include support of research training. In 1930, the Hygienic Laboratory was redesignated by an Act of Congress as the National Institute of Health. In this legislation (PL 71-251) the first authority was given for the establishment of fellowships within the NIH. The Institute was authorized to assume training responsibilities in the area of its interest.

> Sec. 3. Individual scientists, other than commissioned officers of the Public Health Service, designated by the Surgeon General to receive fellowships may be appointed for duty in the National Institute of Health established in this act. During the period of such fellowships these appointees shall hold appointments under regulations promulgated by the Secretary of the Treasury and shall be subject to administrative regulations for the conduct of the Public Health Service. Scientists so selected *may likewise be designated for the prosecution of investigations in other localities and institutions* in this and other countries during the term of their fellowships. (emphasis added)

The direct training authority was extended in 1937 by the Act that established the National Cancer Institute (PL 75-244) and its National Advisory Council.

> Sec. 2. The Surgeon General of the Public Health Service is authorized and directed:
>
> (d) To provide *training* and *instruction* in *technical matters* relating to the *diagnosis* and *treatment* of cancer;
>
> (e) To provide *fellowships* in the Institute from funds appropriated or donated for such purposes. (emphasis added)

During World War II the crucial need for research scientists was again brought to the attention of the nation. The research training program

necessary for maintaining an adequate force of trained scientists became a matter of great import. As a means of assuring an adequate and continuous pool of trained scientific personnel, Vannevar Bush, Director of the war time Office of Scientific Research and Development, recommended in the summer of 1945 that a National Research Agency be established and funded by Congress "for promoting the flow of new scientific knowledge and the development of scientific talent in our youth." After extended debate in Congress on the purposes, prerogatives, and authority of such an agency, the National Science Foundation (NSF) was established in 1950. Among the purposes of the Foundation was that of "awarding scholarships and graduate fellowships in the mathematical, physical, medical, biological, engineering, and other sciences." The NSF was charged with the formulation of a broad national policy designed to assure "that the scope and the quality of basic research in this country were adequate for national security and technological progress." The research program of the Foundation was not intended to supersede the basic research programs of other agencies, but it was given the responsibility for a continuing analysis of the whole national endeavor in basic research, including the evaluation of the research programs of other Federal agencies.

In 1944, by the Public Health Service Act (PL 78-410), the Surgeon General, and through him the NIH, was given the general authority to conduct research both intramurally and extramurally. Sec. 301 of this law established the Public Health Service (PHS) as a granting agency in the area of the medical sciences.

> Sec. 301 (d). The Surgeon General shall conduct in the Service and encourage, cooperate with, and render assistance to other appropriate public authorities, scientific institutions, and scientists in the conduct of, and promote the coordination of, research, investigations, experiments, demonstrations, and studies relating to the causes, diagnosis, treatment, control, and prevention of the physical and mental diseases and impairments of man . . .

In carrying out the foregoing assignment, the Surgeon General was authorized by the Congress in PL 78-410, and subsequent amendments thereto, to "make grants-in-aid to universities, hospitals, laboratories and other private institutions and to individuals" for such research projects as were recommended by the National Advisory Health Council and the National Advisory Councils appointed for each Institute.

In 1946 the National Mental Health Act (PL 79-487) established a National Advisory Council on Mental Health and a broad program of grants with explicit authority for the support of training and instruction.

> Sec. 303. In carrying out the purposes of section 301 *with respect* to *mental health*, the Surgeon General is authorized . . .
>
> (1) To *provide training* and *instruction*, in matters relating to psychiatric disorders to persons found by him to have proper qualifications, and to fix and pay to any of such persons as he may designate a per diem allowance during such training and instruction of not to exceed $10, the number of such persons receiving such training and instruction to be fixed by the National Advisory Mental Health Council; and
>
> (2) to provide such training and instruction, and demonstrations, *through grants*, upon recommendation of the National Advisory Mental Health Council, to public and other nonprofit institutions, but only to the extent necessary for the purposes of such training and instruction. (emphasis added)

Late in 1945 a Research Grants Division (later named the Division of Research Grants) was established in the NIH to administer (1) the projects that were being transferred from the wartime Office of Research and Development to the Public Health Service at the end of the World War II and

(2) the extramural research grants and fellowships of the U.S. Public Health Service as these developed under the authorization carried in the Public Health Act. The mechanics for providing support for research and fellowship programs in medical and related sciences were thus established in the NIH. During 1948, research grants and fellowship awards amounted to nearly $9 million. The related NSF program would make its first awards in 1950.

The National Heart Act (PL 80-655) in 1948 authorized the establishment of the National Heart Institute and changed the name of the National Institute of Health to the National *Institutes* of Health. This act also extended and broadened the training provisions contained in the National Mental Health Act as follows:

> Sec. 412. In carrying out the purposes of section 301 *with respect to heart diseases*, the Surgeon General, through the [National Heart] Institute . . . shall . . .
>
> (g) In accordance with regulations and from funds appropriated or donated for the purpose (1) establish and maintain research fellowships in the Institute and elsewhere with such stipends and allowances (including travel and subsistence expenses) as he may deem necessary to train research workers and procure the assistance of the most brilliant and promising research fellows from the United States and abroad, and, in addition, *provide for such fellowships through grants*, upon recommendation of the [National Advisory Heart] Council, *to public and other nonprofit institutions;* and (2) *provide training and instruction and establish and maintain traineeships*, in *the Institute and elsewhere in matters relating to the diagnosis, prevention, and treatment of heart diseases* with such stipends and allowances (including travel and subsistence expenses) for trainees as he may deem necessary, the number of persons receiving such training and instruction, and the number of persons holding such traineeships, to be fixed by the Council, and, in addition, *provide for such training, instruction, and traineeships through grants*, upon recommendation of the Council, *to public and other nonprofit institutions.*
>
> Sec. 414. The Council is authorized to . . .
>
> (c) review applications from any public or other nonprofit institution for *grants-in-aid for training, instruction, and traineeships* in matters relating to the diagnosis, prevention, and treatment of heart diseases, and certify to the Surgeon General its approval of such applications for grants-in-aid as it determines will best carry out the purposes of this Act . . .

By 1950 seven institutes had been authorized and established as components of the "National Institutes of Health." These were:

Date Established	Name	Public Law
1937	National Cancer Institute (NCI)	75-244
1946*	National Institute of Mental Health (NIMH)	79-487
1948	National Heart Institute (NHI)	80-655
1948	National Institute of Dental Research (NIDR)	80-755
1948	National Institute of Allergy and Infectious Diseases (NIAID)	Administrative action
1950	National Institute of Arthritis and Metabolic Diseases (NIAMD)	81-692
1950	National Institute of Neurological Diseases and Blindness (NINDB)	81-692

*Established as the Division of Mental Hygiene in 1946, renamed as the National Institute of Mental Health in 1949, and separated from the NIH and raised to bureau status in the PHS by a PHS reorganization effective January 1, 1967.

The PHS Acts Amendments (PL 81-692), which established the NIAMD and NINDB, extended the training authority to the institutes already in existence or to be established in the future, where such training authorities were not otherwise provided:

> Sec. 433 (a). Where an institute has been established under this part, the Surgeon General shall carry out the purposes of section 301 with respect to the conduct and support of research relating to the disease or diseases to which the activities of the institute are directed (including grants-in-aid for drawing plans, erection of buildings, and acquisition of land therefor), through such institute and in cooperation with the national advisory council established or expanded by reason of the establishment of such institute. In addition, the Surgeon General is authorized to provide training and instruction and establish and maintain traineeships and fellowships, in such institute and elsewhere, in matters relating to the diagnosis, prevention, and treatment of such disease or diseases with such stipends and allowances (including travel and subsistence expenses) for trainees and fellows as he may deem necessary, and, in addition, provide for such training, instruction, and traineeships and for such fellowships through grants to public and other nonprofit institutions. The provisions of this subsection shall also be applicable to any institute established by any other provision of this Act to the extent that such institute does not already have the authority conferred by this subsection.

The authority for the support of training and instruction was rather specifically pointed to "professional training related to the cause, prevention, methods of diagnosis, and treatment" of the particular disease or group of diseases constituting the scope of activity of the particular institute. Because of restrictions in their responsibilities and prerogatives arising from their "disease orientation" designations, these institutes have become known as the "categorical institutes."

In 1946, the Division of Research Grants (later sometimes called the Division of Research Grants and Fellowships) was given the responsibility in the NIH of operating and administering a program of extramural research grants and fellowships of both a categorical or a noncategorical nature. Initially, 21 study sections were appointed to consider applications for grants and to make recommendations to the various National Advisory Councils whose function it was to advise the Surgeon General on the worth of the applications. These study sections were broad enough in the areas covered to allow consideration of applications from any basic area of medical and related sciences.

The purpose of the Research Grants program inaugurated at that time under authority of the Public Health Service Act (1944) was:

> . . . to stimulate research in medical and allied fields, research that would not be undertaken otherwise because of lack of support, by making available funds for such research and actively encouraging scientific investigation of specific problems on which scientists agree that urgently needed information is lacking. Accompanying this purpose is complete acceptance of a basic tenet of the philosophy upon which the scientific method rests: the integrity and independence of the research worker and his freedom from control, direction, regimentation and outside interference.

The purpose of the Research Fellowship program established in 1945 under the same authorization was:

> . . . to further the development and training of competent research workers in the medical sciences and related fields . . . and is closely

related to the purposes of the Research Grants program. [These fellowships were to be available]. . .to individuals who have had postgraduate work in institutions of recognized standing in the various fields of medicine and related sciences, such as biology, chemistry, physics, and entomology, public health, medicine, dentistry, veterinary medicine and others.[27]

A primary objective of the Fellowship Award program was to stimulate promising young scientists toward the improvement of their research capabilities. It could also serve to increase and upgrade the scientific manpower pool available to carry on the needed research and teaching in the medical sciences. The Research Grant program was established to stimulate and encourage existing trained scientists to carry on studies needed to expand knowledge in the critical health-related fields. Both programs could function, however, only through existing training centers (e.g. established universities) and would not serve, directly, to stimulate the establishment of new training centers nor the improvement of the quality of existing centers. Neither of these modes of support would have much direct influence upon the population of scientific personnel to whom such grants and awards could be assigned.

At least two circumstances had to be provided to stimulate an increase in supply and quality of scientific manpower. First, the number of undergraduate and graduate students who would eventually enter this area of endeavor had to be increased. Secondly, the number of training institutions offering the required training had to be expanded and the quality of training offered by established training institutions, as well as by newly formed institutions of that type, had to be improved. These goals could be achieved by granting *support* (1) to students who were interested but as yet uncommitted to the training disciplines that were needed and (2) to institutions, also interested and either committed to or not yet committed to offering training in these disciplines.

The "training and instruction" authority accorded the Institutes in their fields of interest was pointed toward the goal of increasing the supply of manpower capable of carrying out duties "in matters related to the diagnosis, prevention, and treatment" of the disease category of the particular institute involved. These categorical limitations severely restricted the kinds of training that could be supported by a given institute. There exist many fields of basic knowledge that impinge upon the problems relevant to the disease assignments of a given institute but that are of such broad significance and application as to apply as well to the problems of all the others. It was recognized that training programs would need to be given support that (1) was of such a nature as to apply to the problems of more than one institute and (2) was not necessarily categorically oriented. As in the case of the Research Grant program and the Fellowship Award program, a mechanism was needed through which support of training and instruction programs could be given not only in the categorical areas of health-related problems but in all the basic areas of the field as well.

Correlated with a main objective of the Federal granting program, i.e. that of increasing the size and quality of the nation's scientific manpower pool, is the need that the areas of manpower shortages be identified and that the shortages be rectified through support of training programs focused on these areas. Two such fields in which a critical shortage of well trained persons was early recognized and for which a training program could not be restricted, as to interest and application, to any single categorical institute, were the disciplines of biometry and epidemiology.

Early in 1953 the National Advisory Health Council adopted a resolution that recommended that the PHS stimulate appropriate schools of

[27] C. J. Van Slyke, "New Horizons in Medical Research," *Science*, CIV (1946) 559.

public health to undertake more active programs for training biostatisticians for research careers. Following visits by a subcommittee of the National Advisory Health Council, a number of applications from accredited schools of public health were submitted. There existed, however, no mechanism through which an area of wide, noncategorically limited, application, such as biometry, could be accorded support for training programs. In recognition of the dire need that training programs in biometry be initiated without delay, the National Advisory Heart Council recommended that support be provided, on a one-year basis, by the National Heart Institute. Six programs were approved for support in 1953. In 1954 the National Advisory Heart Council unanimously recommended reaffirmation of its intent to continue support of the programs in these schools for an additional five years. Other schools were included in the program during 1955-1956. In 1956 the National Advisory Cancer Council recommended approval of an epidemiology training grant. In the same year, as a move designed to simplify their management, the Division of Research Grants accepted responsibility for administering the training programs in these two areas, epidemiology and biometry, with funds allocated from six institutes for this purpose. Thus, the need for training grant support in fields that could not be logically assigned to any single categorical institute was recognized, and a mechanism was inaugurated through which support could be given to such programs from funds that were originally appropriated to the individual institutes.

It was already becoming apparent that a considerable expansion of support into the various areas of the basic health-related sciences was needed in order to stimulate the increase in the manpower pool that was required for carrying on essential research programs. Training in any of the basic medical sciences could be expected to be utilizable in others, and in the more applied areas as well. It was argued that training program support should be accorded to all basic health-related sciences similar to that which was currently being given the already designated areas of scarcity, biometry and epidemiology.

> Many of the Institutes attempted to take care of these needs insofar as possible but, because of the importance of such areas, various Study Sections, Councils, and Institutes urged that a special basic science training program be established. In October, 1957, the first announcement went out to academic institutions throughout the country that funds were available for the support of graduate training in the basic medical sciences. . . .Early in 1958, under the administration of the Division of Research Grants and with the strong support of all the Institutes, two meetings were held of a new "General Research Training Committee" . . . . This Committee recommended the approval of about $800,000 worth of training grants. This, then, was the start of a program directly supporting training in the basic medical sciences.[78]

As an outgrowth of these and other forces, in June 1958 a new division in the Institutes, the Division of General Medical Sciences (DGMS) was formed by congressional directive. It was chartered to promote "research and training through grants in all scientific fields basic to general medicine, aging and public health, including the clinical and preclinical sciences." Thus, for the first time, Congress directed the Public Health Service to support training in the basic sciences without the necessity that this training be associated with a particular disease or condition. In its function this division would be noncategorically oriented in contrast to the

[78]Frederick L. Stone, "A Brief History of the Research Training Grants Program at the National Institutes of Health" (January 1959).

categorical orientation of the institutes themselves. Administratively the new division consisted of:

1. A Research Training Branch charged with the responsibility of promoting and directing biomedical research training programs (involving the awarding of training grants in biomedical research training areas), the establishment of research fellowships in these areas, and the development of experimental training programs in medical schools and related institutions. It would promote increased training opportunities in epidemiology, biometry, genetics, anatomy, biochemistry, pathology, physiology, pharmacology, nurse research, and other special disciplines or areas.

2. A General Research Grants Branch to administer grant programs in basic medical sciences relating to general medicine, aging, and public health, including clinical and preclinical sciences.

3. A Center for Aging Research Branch (transferred from the National Heart Institute) to direct a program aimed at bringing the full range of biological, physiological, and social science research to bear on the phenomenon of aging. (This branch was transferred to the NICHD in 1965.)

In 1962, under PHS Act Amendment (PL 87-838), The Division of General Medical Sciences was raised to "institute" status and given the name, National Institute of General Medical Sciences (NIGMS). At the same time Congress authorized the establishment of a new Institute of Child Health and Human Development (NICHD).

Authorization for the establishment of the NIGMS, contained in this legislation, reads:

> Sec. 442. The Surgeon General is authorized, with the approval of the Secretary, to establish in the Public Health Service an Institute for the conduct and support of *research* and *research training* in the *general and basic medical sciences and related natural or behavioral sciences* which have significance for two or more other institutes, or are outside the general area of responsibility of any other institute, established under or by this Act.

This Act also specifically stipulated that, in Section 301 (d) of the PHS Act, the phrase "research or research training projects" be used to replace the more limiting phrase "research projects" contained in the original, thereby providing more explicit legislative authority for the training programs of the entire Public Health Service.

Thus the eight institutes other than the NIGMS are authorized to "provide training and instruction" in the areas of their interests. It would also appear that these institutes may "conduct and support research and research training" in these same areas. The NIGMS authorization stipulates that it "conduct and support research and research training in the general or basic medical sciences and related natural and behavioral sciences" with no other limitations than (1) that the program to be supported must be broader in application than can be circumscribed within the area of interest of any single one of the categorical agencies and (2) that the programs to be supported must provide training for *research*.

Since 1958, DGMS and NIGMS research training grants have constituted a major source of NIH support for the training of students in some 30 disciplines in the basic medical sciences. By fiscal year 1967, NIH programs accounted for approximately three fourths of the total Federal support of graduate training in the biosciences (see Table A1). Table 2 in Chapter I shows the NIGMS contribution to training grant and fellowship aid as a percentage of the total NIH effort in these areas. Table A2 indicates how the NIGMS training grant support has been distributed among the various disciplines since 1958.

TABLE A1

Numbers of Graduate and Postdoctoral Students in the Health Sciences Receiving Federal Support, by Sponsoring Agency, Fiscal Year 1967

Sponsoring Agency	Number of Graduate and Postdoctoral Students by Field										
		Biosciences				Behavioral Sciences					
							Psychology				
	Total	Total	Basic Medical	Other Bio-sciences	Clinical Specialties	Total	Total	Clinical	Other	Other Behavioral	Other Health-Related
TOTAL, Graduates and Postdoctorals	**53,534**	**14,216**	**10,494**	**3,722**	**15,804**	**6,148**	**4,356**	**1,845**	**2,511**	**1,792**	**17,366**
Dept. of Health, Educ., and Welfare	39,975	12,301	9,479	2,822	7,333	4,900	3,341	1,371	1,970	1,559	15,441
National Institutes of Health	16,746	10,744	8,574	2,170	4,415	620	413	67	346	207	967
Bureau of Health Manpower	6,349	-----	-----	-----	-----	-----	-----	-----	-----	-----	6,349
National Inst. of Mental Health	8,847	294	292	2	2,472	3,126	2,317	1,192	1,125	809	2,955
Social Rehabilitation Service	5,103	36	1	35	303	179	145	45	100	34	4,585
Office of Education	1,779	907	357	550	-----	872	399	-----	399	473	-----
Other DHEW	1,151	320	255	65	143	103	67	67	-----	36	583
Department of Defense	5,110	280	239	41	4,328	15	15	9	6	-----	487
Department of State	147	47	38	9	29	-----	-----	-----	-----	-----	71
Atomic Energy Commission	137	61	22	39	2	-----	-----	-----	-----	-----	74
National Aeronautics and Space Admin.	462	348	289	59	-----	114	112	-----	112	2	-----
National Science Foundation	1,678	1,179	427	752	-----	499	268	-----	268	231	-----
Veterans Administration	6,025	-----	-----	-----	4,112	620	620	465	155	-----	1,293
TOTAL, Graduate Students	**35,611**	**11,533**	**8,433**	**3,100**	**1,652**	**5,692**	**3,949**	**1,756**	**2,193**	**1,743**	**16,734**
Dept. of Health, Educ., and Welfare	30,526	9,785	7,535	2,250	1,273	4,472	2,962	1,289	1,673	1,510	14,996
National Institutes of Health	11,010	8,415	6,808	1,607	1,257	527	333	63	270	194	811
Bureau of Health Manpower	6,227	-----	-----	-----	-----	-----	-----	-----	-----	-----	6,227
National Inst. of Mental Health	5,842	134	133	1	-----	2,808	2,031	1,127	904	777	2,900
Social Rehabilitation Service	4,749	29	-----	29	-----	179	145	45	100	34	4,541
Office of Education	1,779	907	357	550	-----	872	399	-----	399	473	-----
Other DHEW	919	300	237	63	16	86	54	54	-----	32	517
Department of Defense	980	255	227	28	378	13	13	8	5	-----	334
Department of State	50	9	3	6	1	-----	-----	-----	-----	-----	40
Atomic Energy Commission	117	44	12	32	-----	-----	-----	-----	-----	-----	73
National Aeronautics and Space Admin.	456	342	283	59	-----	114	112	-----	112	2	-----
National Science Foundation	1,579	1,098	373	725	-----	481	250	-----	250	231	-----
Veterans Administration	1,903	-----	-----	-----	-----	612	612	459	153	-----	1,291
TOTAL, Postdoctoral Students	**17,923**	**2,683**	**2,061**	**622**	**14,152**	**456**	**407**	**89**	**318**	**49**	**632**
Dept. of Health, Educ., and Welfare	9,449	2,516	1,944	572	6,060	428	379	82	297	49	445
National Institutes of Health	5,736	2,329	1,766	563	3,158	93	80	4	76	13	156
Bureau of Health Manpower	122	-----	-----	-----	-----	-----	-----	-----	-----	-----	122
National Inst. of Mental Health	3,005	160	159	1	2,472	318	286	65	221	32	55
Social Rehabilitation Service	354	7	1	6	303	-----	-----	-----	-----	-----	44
Office of Education	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Other DHEW	232	20	18	2	127	17	13	13	-----	4	68
Department of Defense	4,130	25	12	13	3,950	2	2	1	1	-----	153
Department of State	97	38	35	3	28	-----	-----	-----	-----	-----	31
Atomic Energy Commission	20	17	10	7	2	-----	-----	-----	-----	-----	1
National Aeronautics and Space Admin.	6	6	6	-----	-----	-----	-----	-----	-----	-----	-----
National Science Foundation	99	81	54	27	-----	18	18	-----	18	-----	-----
Veterans Administraiton	4,122	-----	-----	-----	4,112	8	8	6	2	-----	2

Source: *National Institutes of Health, Resources Analysis Memo No. 11.*

TABLE A2

Percentage Distribution of Total NIGMS Training Grant Support, by Training Field, Fiscal Years 1958-1968

Field of Training	Percent of Total Funds by Fiscal Year										
	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
TOTAL All Fields	99.9	100.0	100.0	99.8	100.1	100.0	99.8	100.2	100.2	99.8	100.0
Anatomical Sciences	5.6	7.4	6.7	7.3	6.4	5.7	6.1	6.4	5.9	6.2	5.6
Anesthesiology	2.0	1.8	1.1	1.0	1.0	0.9	0.9	1.1	2.4	2.6	2.8
Clinical Anesthesiology	–	–	–	–	–	–	–	–	–	2.3	2.2
Behavioral Sciences	–	–	–	–	0.6	1.2	2.8	3.5	3.7	5.5	4.2
Biochemistry	9.8	17.5	15.7	13.3	12.5	11.6	12.8	12.7	12.3	12.0	11.8
Bio-information	–	0.7	0.5	0.5	0.5	0.4	0.4	0.1	[a]		
Biomedical Engineering	–	–	–	0.5	0.6	0.7	1.5	1.6	2.3	3.0	3.0
Biometry	17.1	9.9	7.3	5.7	6.0	6.5	7.0	6.8	6.2	5.0	5.9
Biophysical Sciences	–	–	–	4.9	7.1	6.0	6.2	6.4	6.0	5.8	5.7
Continuing Scientific Development	–	–	–	–	–	–	–	0.1	0.2	–	–
Dermatology	0.7	1.1	1.7	[b]							
Developmental Sciences	0.9	5.0	6.1	3.7	5.2	4.1	[c]				
Environmental Sciences	–	–	–	2.7	2.6	3.7	[d]				
Epidemiology	20.4	12.2	7.4	5.0	4.7	4.0	3.7	3.1	2.6	1.7	2.5
Evaluation	–	–	0.4	0.2	0.2	0.2	0.1	0.1	0.1	[e]	
Experimental Colleges	–	–	1.0	0.6	1.3	1.2	1.2	0.9	0.8	0.8	1.7
Genetics	4.9	5.3	7.7	8.4	7.2	6.6	7.1	7.4	6.4	6.2	6.1
Laboratory Animal Sciences	–	–	–	–	–	–	–	0.6	0.7	–	–
Medicinal Chemistry	–	–	–	–	0.3	0.4	0.5	0.5	0.6	1.1	0.8
Medical Scientist	–	–	–	–	–	–	1.0	0.9	1.6	2.1	3.2
Medical Student	16.9	8.0	3.7	3.3	3.1	4.1	3.8	3.7	3.0	0.8	[f]
Microbiology	–	–	7.1	7.4	8.5	7.9	7.4	7.3	6.7	6.1	6.5
Multi-biological Sciences	–	1.0	1.0	0.3	0.5	1.4	3.4	4.0	3.7	3.8	4.2
Multi-medical Sciences	–	1.0	1.4	2.2	1.9	2.0	2.1	1.5	1.1	1.1	1.0
Nursing	–	–	–	–	0.3	0.8	[g]				
Nutrition	–	0.2	0.6	1.8	1.3	1.4	1.5	1.8	1.7	1.5	1.6
Pathology	16.4	13.6	13.1	12.3	11.7	11.3	10.8	10.5	9.6	8.5	9.1
Pharmacology	4.7	9.2	9.5	8.8	7.5	7.7	8.4	8.4	8.2	7.1	7.5
Clinical Pharmacology	–	–	–	–	–	–	–	0.3	0.4	0.8	0.8
Physiology	0.5	4.6	6.4	8.3	8.1	9.1	8.4	8.1	6.8	6.4	6.0
Radiology	–	–	–	–	–	–	0.5	0.6	2.8	3.4	3.5
Surgery	–	–	0.7	0.4	0.6	0.5	0.6	0.5	3.1	4.1	4.2
Taxicology	–	–	0.1	0.1	0.1	0.1	0.6	0.8	0.9	1.3	1.1
Scientific Planning and Evaluation	–	1.5	0.8	1.1	0.3	0.5	1.1	0.5	0.5	0.6	[h]

[a] *Transferred to National Library of Medicine (1966)*
[b] *Transferred to NIAMD (1961)*
[c] *Transferred to NICHD (1964)*
[d] *Transferred to Environmental Health (1964)*
[e] *Phased out (1967)*
[f] *Phased out (1968)*
[g] *Transferred to Division of Nursing (1964)*
[h] *Not available and not taken into account in calculation of percentage distribution in the 1968 column*

Source: *NIGMS, Research Training Grants Branch.*

APPENDIX B

NIGMS Academic Specialties Lists

Most of the tabulations in this report specify fourteen academic fields plus "All Other" and "Unknown." The field of training of NIGMS trainees was taken from the academic specialty of the review committee that considered the training grant application. The specialties list for these committees is Appendix F in the NIGMS coding manual.

The field of training for NIGMS fellows is coded from the NIGMS "Discipline/Specialty/Field (D/S/F) Codes." The following table shows the relationships among the fields used in this report, Appendix F of the NIGMS coding manual, and the D/S/F codes.

Training Fields Used in this Report	Trainee Fields from Training Committee Specialties List (Appendix F)	Fellowship Fields From D/S/F codes
Biochemistry	Biochemistry	Biochemistry
Pathology	Pathology	Pathology
Physiology	Physiology	Physiology
Microbiology	Microbiology	Microbiology
Pharmacology	Pharmacology	Pharmacology
Biometrics	Biomathematics	Biostatistics
	Biometry	Biometrics
	Computer Research	Biometry
		Computer Programming
		Mathematical Biostatistics
		Public Health Statistics
		Mental Health Statistics
Anatomical Sciences	Anatomical Sciences	Anatomy
Biophysics	Biophysical Sciences	Biophysics
		Radiology
Genetics	Genetics	Genetics
Other Biosciences	Epidemiology	Entomology
	Multidisciplinary Biology	Hydrobiology
		Ecology
	Cell Biology	Cell Biology
	Toxicology	Zoology, NEC
		Botany, NEC
		Biology, NEC
		Other General Medical and Biosciences
Chemistry	Medicinal Chemistry	Polymer Chemistry
	Clinical Chemistry	Organic Synthesis
		Medicinal & Pharmaceutical
		Organic Chemistry
		Physical Chemistry
		Inorganic Chemistry
		Analytical Chemistry
		Other Chemistry

Training Fields Used in this Report	Trainee Fields from Training Committee Specialties List (Appendix F)	Fellowship Fields From D/S/F codes
Physical Sciences & Engineering (excl. Chem.)	Biomedical Engineering	Engineering, health-related Engineering Mathematics Physics Earth and related sciences
Health Sciences	Anesthesiology Clinical Research[a] Medical Scientist Multidisciplinary Medicine Nutritional Sciences Clinical Pharmacology	Multidisciplinary medicine Radiation, nonclinical Nutrition Internal Medicine Allergy Pediatrics Obstetrics Gynecology Surgery Otorhinolaryngology Neuropsychiatry Neurology Psychiatry Preventive Medicine Other Clinical Medicine Clinical Dentistry Health Administration Nursing Veterinary Medicine Pharmacy Accident Prevention Disease Prevention & Control Dental Public Health Mental Health Water Pollution Control Air Pollution Control Environmental Engineering Food Protection Occupational Health
Medical Students	Medical Student Research	(No program in this area)
All other	Evaluation Behavioral Sciences Bio-Information Experimental Colleges Lab. Animal Sciences Continuing Scientific Development Not elsewhere classified	Psychology Sociology Anthropology Social Work Other Social Sciences Agricultural Fields Not elsewhere classified

[a]Clinical Research included radiology before 1966; since then, radiology has been a separate field.

APPENDIX C

State and Regional Summary of Graduate Education and Financial Support in Selected Bioscience Fields[a]

[a] *The selected bioscience fields include biochemistry, pathology, physiology, microbiology, pharmacology, biometrics, anatomy, biophysics, and genetics.*

SOURCE: *NIGMS, Statement of Appointment of Trainee and Fellowship Award Statements.* NIGMS Summary of Grants & Awards – FY 1967. *National Science Foundation,* Federal Support to Universities & Colleges FY 1963-1966 *(NSF 67-14). United States Office of Education,* Enrollment for Advanced Degrees, Fall 1964. National Research Council, Office of Scientific Personnel, Doctorate Records File.

APPENDIX C

State and Regional Summary of Graduate Education and Financial Support in Selected Bioscience Fields

State and Region	Number of Bioscience Graduate Students Fiscal Year 1965						Number of PhD-Granting Departments in Selected Bioscience Fields, Fiscal Years 1958-1967						Number of PhD's in Selected Bioscience Fields, Fiscal Year 1967					
	Total		Full-time		Part-time		Total		With NIGMS Support		Without NIGMS Support		Total		With NIGMS Traineeship		Without NIGMS Traineeship	
	Number	Per-cent	Number	Per-cent	Number	Per-cent	Number	Per-cent	Number	Per-cent	Number	Per-cent	Number	Per-cent	Number	Per-cent	Number	Per-cent
TOTAL All States	9,776	99.8	7,226	99.8	2,550	99.8	894	100.1	448	100.7	446	99.8	2,423	99.8	712	99.7	1,711	100.1
Maine	7	0.1	5	0.1	2	0.1	1	0.1	–	–	1	0.2	–	–	–	–	–	–
New Hampshire	25	0.3	24	0.3	1	–	7	0.8	1	0.2	6	1.3	6	0.2	–	–	6	0.4
Vermont	43	0.4	36	0.5	7	0.3	5	0.6	3	0.7	2	0.4	3	0.1	1	0.1	2	0.1
Massachusetts	275	2.8	250	3.4	25	1.0	49	5.5	21	4.7	28	6.3	114	4.7	45	6.3	69	4.0
Rhode Island	27	0.3	14	0.2	13	0.5	11	1.2	3	0.7	8	1.8	11	0.5	3	0.4	8	0.5
Connecticut	219	2.2	170	2.4	49	1.9	16	1.8	13	2.9	3	0.7	52	2.1	24	3.4	28	1.6
TOTAL, New England	596	6.1	499	6.9	97	3.8	89	10.0	41	9.2	48	10.7	186	7.7	73	10.2	113	6.6
New York	918	9.4	654	9.0	264	10.3	100	11.2	56	12.5	44	9.9	229	9.5	67	9.4	162	9.5
New Jersey	178	1.8	106	1.5	72	2.8	17	1.9	6	1.3	11	2.5	41	1.7	12	1.7	29	1.7
Pennsylvania	456	4.7	272	3.8	184	7.2	57	6.4	22	4.9	35	7.8	103	4.2	33	4.6	70	4.1
TOTAL, Middle Atlantic	1,552	15.9	1,032	14.3	520	20.3	174	19.5	84	18.7	90	20.2	373	15.4	112	15.7	261	15.3
Ohio	340	3.5	265	3.7	75	2.9	30	3.3	17	3.8	13	2.9	65	2.7	9	1.3	56	3.3
Indiana	251	2.6	239	3.3	12	0.5	23	2.6	11	2.5	12	2.7	106	4.4	28	3.9	78	4.5
Illinois	688	7.0	536	7.4	152	5.9	42	4.7	28	6.2	14	3.1	132	5.4	64	9.0	68	4.0
Michigan	370	3.8	269	3.7	101	4.0	24	2.7	16	3.6	8	1.8	100	4.1	32	4.5	68	4.0
Wisconsin	360	3.7	299	4.1	61	2.4	14	1.6	10	2.2	4	0.9	91	3.8	28	3.9	63	3.7
TOTAL, East North Central	2,009	20.6	1,608	22.2	401	15.7	133	14.9	82	18.3	51	11.4	494	20.4	161	22.6	333	19.5
Minnesota	321	3.3	161	2.2	160	6.3	10	1.1	9	2.0	1	0.2	76	3.1	27	3.8	49	2.8
Iowa	272	2.8	252	3.5	20	0.8	17	1.9	11	2.5	6	1.3	58	2.4	8	1.1	50	2.9
Missouri	212	2.2	140	1.9	72	2.8	24	2.7	12	2.7	12	2.7	36	1.5	8	1.1	28	1.6
North Dakota	54	0.5	48	0.7	6	0.2	8	0.9	2	0.4	6	1.3	6	0.2	1	0.1	5	0.3
South Dakota	18	0.2	17	0.2	1	–	8	0.9	–	–	8	1.8	8	0.3	–	–	8	0.5
Nebraska	78	0.8	30	0.4	48	1.9	7	0.8	3	0.7	4	0.9	26	1.1	4	0.6	22	1.3
Kansas	199	2.0	98	1.4	101	4.0	16	1.8	9	2.0	7	1.5	53	2.2	9	1.3	44	2.6
TOTAL, West North Central	1,154	11.8	746	10.3	408	16.0	90	10.1	46	10.3	44	9.9	263	10.8	57	8.0	206	12.0
Delaware	–	–	–	–	–	–	4	0.4	–	–	4	0.9	6	0.2	–	–	6	0.3
Maryland	306	3.1	257	3.5	49	1.9	16	1.8	14	3.1	2	0.4	58	2.4	27	3.8	31	1.8
District of Columbia	218	2.2	136	1.9	82	3.2	25	2.8	5	1.1	20	4.5	27	1.1	5	0.7	22	1.3
Virginia	70	0.7	59	0.8	11	0.4	16	1.8	4	0.9	12	2.7	20	0.8	3	0.4	17	1.0
West Virginia	90	0.9	43	0.6	47	1.8	7	0.8	4	0.9	3	0.7	15	0.6	8	1.1	7	0.4
North Carolina	273	2.8	200	2.8	73	2.9	23	2.6	14	3.1	9	2.0	95	3.9	32	4.5	63	3.7
South Carolina	36	0.4	36	0.5	–	–	7	0.8	–	–	7	1.6	10	0.4	–	–	10	0.6
Georgia	117	1.2	58	0.8	59	2.3	12	1.3	7	1.6	5	1.1	39	1.6	5	0.7	34	2.0
Florida	131	1.3	103	1.4	28	1.1	19	2.1	12	2.7	7	1.6	43	1.8	11	1.5	32	1.9
TOTAL, South Atlantic	1,241	12.6	892	12.3	349	13.6	129	14.4	60	13.4	69	15.5	313	12.9	91	12.7	222	13.0
Kentucky	72	0.7	46	0.6	26	1.0	12	1.3	5	1.1	7	1.6	19	0.8	6	0.8	13	0.8
Tennessee	203	2.1	164	2.3	39	1.5	18	2.0	14	3.1	4	0.9	25	1.0	11	1.5	14	0.8
Alabama	61	0.6	31	0.4	30	1.2	8	0.9	3	0.7	5	1.1	13	0.5	1	0.1	12	0.7
Mississippi	62	0.6	56	0.8	6	0.2	13	1.5	3	0.7	10	2.2	17	0.7	5	0.7	12	0.7
TOTAL, East South Central	398	4.0	297	4.1	101	3.9	51	5.7	25	5.6	26	5.8	74	3.0	23	3.2	51	3.0
Arkansas	66	0.7	40	0.5	26	1.0	5	0.6	4	0.9	1	0.2	11	0.4	6	0.8	5	0.3
Louisiana	191	1.9	160	2.2	31	1.2	14	1.6	9	2.0	5	1.1	53	2.2	17	2.4	36	2.1
Oklahoma	183	1.9	146	2.0	37	1.5	15	1.7	5	1.1	10	2.2	38	1.6	6	0.8	32	1.9
Texas	421	4.3	336	4.6	85	3.3	33	3.7	13	2.9	20	4.5	90	3.7	21	2.9	69	4.0
TOTAL, West South Central	861	8.8	682	9.4	179	7.0	67	7.5	31	6.9	36	8.0	192	7.9	50	7.0	142	8.3
Nevada	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Montana	32	0.3	25	0.3	7	0.3	6	0.7	–	–	6	1.3	17	0.7	–	–	17	1.0
Idaho	9	0.1	2	–	7	0.3	2	0.2	–	–	2	0.4	3	0.1	–	–	3	0.2
Wyoming	7	0.1	3	–	4	0.2	3	0.3	–	–	3	0.7	7	0.3	1	0.1	6	0.3
Colorado	147	1.5	115	1.6	32	1.2	16	1.8	5	1.1	11	2.5	41	1.7	7	1.0	34	2.0
New Mexico	4	–	2	–	2	0.1	2	0.2	–	–	2	0.4	1	–	–	–	1	0.1
Arizona	53	0.5	39	0.5	14	0.5	3	0.3	1	0.2	2	0.4	36	1.5	4	0.6	32	1.9
Utah	108	1.1	86	1.2	22	0.9	18	2.0	8	1.8	10	2.2	29	1.2	8	1.1	21	1.2
TOTAL, Mountain	360	3.6	272	3.7	88	3.5	50	5.6	14	3.1	36	8.0	134	5.5	20	2.8	114	6.7
Washington	196	2.0	164	2.3	32	1.3	16	1.8	13	2.9	3	0.7	57	2.4	22	3.1	35	2.0
Oregon	212	2.1	190	2.6	22	0.9	14	1.6	8	1.8	6	1.3	47	1.9	13	1.8	34	2.0
California	1,141	11.7	793	11.0	348	13.6	75	8.4	42	9.4	33	7.4	282	11.6	87	12.2	195	11.4
Alaska	1	–	–	–	1	–	1	0.1	–	–	1	0.2	–	–	–	–	–	–
Hawaii	55	0.6	51	0.7	4	0.2	5	0.5	2	0.4	3	0.7	8	0.3	3	0.4	5	0.3
TOTAL, Pacific	1,605	16.4	1,198	16.6	407	16.0	111	12.4	65	14.5	46	10.3	394	16.2	125	17.5	269	15.7

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Number of PhD's Total All Fields Fiscal Year 1967		Number of Persons Receiving NIGMS Stipend and Dependency Allowance, All Fields				NIGMS Funds Allocated, All Fields, Fiscal Year 1967				Federal Academic Science Support, All Fields, Fiscal Year 1966				State and Region
Total		Trainees		Fellows		Total Allocation		Training Grants Only		Institutions with NIGMS Support		Institutions without NIGMS Support		
Number	Per-cent	Number	Per-cent	Number	Per-cent	Thousands of Dollars	Per-cent	Thousands of Dollars	Per-cent	Thousands of Dollars	Per-cent	Thousands of Dollars	Per-cent	
20,295	99.8	18,963	99.8	4,418	99.9	136,856	99.8	43,294	99.3	1,923,214	100.0	235,077	99.9	**TOTAL All States**
8	–	3	–	2	0.1	153	0.1	17	–	2,829	0.2	948	0.4	Maine
31	0.2	188	1.0	27	0.6	694	0.5	141	0.3	8,951	0.5	13	–	New Hampshire
8	–	59	0.3	6	0.1	295	0.2	112	0.3	5,046	0.3	493	0.3	Vermont
1,298	6.4	1,289	6.8	543	12.3	11,591	8.4	3,385	7.8	142,459	7.4	10,490	4.5	Massachusetts
109	0.5	157	0.8	17	0.4	755	0.6	378	0.9	17,879	0.9	871	0.4	Rhode Island
392	1.9	512	2.7	156	3.5	3,475	2.5	1,234	2.8	41,183	2.1	1,695	0.7	Connecticut
1,846	9.0	2,208	11.6	751	17.0	16,963	12.4	5,267	12.1	218,347	11.4	14,510	6.2	**TOTAL, New England**
2,447	12.0	2,244	11.8	377	8.5	16,923	12.4	5,244	12.1	216,763	11.3	34,505	14.7	New York
447	2.2	248	1.3	72	1.6	1,311	0.9	406	0.9	37,487	1.9	1,212	0.5	New Jersey
967	4.8	1,201	6.3	165	3.7	7,816	5.7	2,802	6.5	105,777	5.5	10,643	4.5	Pennsylvania
3,861	19.0	3,693	19.5	614	13.9	26,050	19.0	8,452	19.5	360,027	18.7	46,360	19.7	**TOTAL, Middle Atlantic**
749	3.7	690	3.6	124	2.8	3,940	2.9	1,495	3.5	68,042	3.5	16,425	7.0	Ohio
843	4.1	317	1.7	189	4.3	2,[illegible]2	2.0	877	2.0	42,405	2.2	5,028	2.1	Indiana
1,365	6.7	1,261	6.6	355	8.0	7,8[illegible]2	5.8	3,276	7.6	127,219	6.6	6,893	2.9	Illinois
989	4.9	593	3.1	145	3.3	4,115	3.0	1,754	4.0	87,404	4.5	10,512	4.5	Michigan
662	3.3	507	2.7	143	3.2	4,045	3.0	1,200	2.8	42,038	2.2	3,979	1.7	Wisconsin
4,608	22.7	3,368	17.7	956	21.6	31,206	22.8	8,602	19.9	367,108	19.1	42,837	18.2	**TOTAL, East North Central**
406	2.0	511	2.7	43	1.0	2,893	2.1	1,323	3.1	34,435	1.8	7,896	3.4	Minnesota
535	2.6	237	1.2	101	2.3	2,368	1.7	485	1.1	23,280	1.2	3,530	1.5	Iowa
418	2.1	594	3.1	50	1.1	2,078	1.5	626	1.4	44,998	2.3	4,195	1.8	Missouri
40	0.2	37	0.2	22	0.5	161	0.1	97	0.2	1,204	0.1	3,229	1.4	North Dakota
28	0.1	–	–	3	0.1	24	–	–	–	1,242	0.1	4,109	1.7	South Dakota
169	0.8	69	0.4	12	0.3	221	0.2	60	0.1	9,959	0.5	519	0.2	Nebraska
237	1.2	306	1.6	74	1.7	1,233	0.9	576	1.3	18,533	1.0	1,639	0.7	Kansas
1,833	9.0	1,754	9.2	305	6.9	8,978	6.5	3,167	7.3	133,651	6.9	25,117	10.7	**TOTAL, West North Central**
48	0.2	–	–	11	0.2	87	0.1	–	–	3,599	0.2	484	0.2	Delaware
354	1.7	992	5.2	177	4.0	5,272	3.8	1,914	4.4	51,492	2.7	2,373	1.0	Maryland
322	1.6	137	0.7	53	1.2	734	0.5	158	0.4	23,644	1.2	791	0.3	District of Columbia
203	1.0	198	1.0	28	0.6	798	0.6	196	0.5	20,307	1.0	3,349	1.4	Virginia
49	0.2	76	0.4	4	0.1	77	0.1	60	0.1	7,408	0.4	1,128	0.5	West Virginia
439	2.2	591	3.1	85	1.9	4,496	3.3	1,793	4.1	56,718	3.0	4,325	1.8	North Carolina
44	0.2	6	–	2	0.1	122	0.1	12	–	8,460	0.4	617	0.3	South Carolina
226	1.1	160	0.8	42	1.0	1,604	1.2	501	1.2	27,522	1.4	2,027	0.9	Georgia
421	2.1	391	2.1	60	1.3	1,969	1.4	861	2.0	44,899	2.3	1,573	0.7	Florida
2,106	10.4	2,551	13.4	462	10.4	15,159	11.1	5,495	12.7	244,049	12.7	16,667	7.1	**TOTAL, South Atlantic**
105	0.5	100	0.5	63	1.4	758	0.5	270	0.6	1[illegible],872	1.[illegible]	4,335	1.8	Kentucky
215	1.1	361	1.9	65	1.5	1,794	1.3	664	1.5	27,[illegible]3	1.4	4,290	1.8	Tennessee
127	0.6	89	0.5	10	0.2	361	0.3	156	0.4	14,882	0.8	2,763	1.2	Alabama
93	0.5	119	0.6	21	0.5	266	0.2	193	0.4	4,395	0.2	8,106	3.5	Mississippi
540	2.7	669	3.5	159	3.6	3,179	2.3	1,292	2.9	66,452	3.5	19,494	8.3	**TOTAL, East South Central**
81	0.4	125	0.7	44	1.0	163	0.1	46	0.1	8,202	0.4	1,313	0.6	Arkansas
273	1.3	428	2.2	44	1.0	1,178	0.9	638	1.5	30,195	1.6	4,036	1.7	Louisiana
366	1.8	152	0.8	36	0.8	586	0.4	187	0.4	15,141	0.8	1,575	0.7	Oklahoma
777	3.8	567	3.0	74	1.7	4,684	3.4	1,081	2.5	71,829	3.7	14,229	6.0	Texas
1,497	7.4	1,272	6.7	198	4.5	6,611	4.8	1,952	4.5	125,367	6.5	21,153	9.0	**TOTAL, West South Central**
6	–	–	–	–	–	–	–	–	–	–	–	3,123	1.3	Nevada
49	0.2	1	–	8	0.2	56	–	–	–	3,645	0.2	1,252	0.5	Montana
15	0.1	–	–	24	0.5	–	–	–	–	2,925	0.2	369	0.2	Idaho
45	0.2	–	–	3	0.1	111	0.1	–	–	3,444	0.2	4	–	Wyoming
379	1.9	243	1.3	72	1.6	1,492	1.1	558	1.3	26,129	1.4	9,490	4.0	Colorado
85	0.4	15	0.1	1	–	73	0.1	–	–	191	–	13,017	5.5	New Mexico
235	1.2	39	0.2	14	0.3	475	0.3	101	0.2	17,638	0.9	1,134	0.5	Arizona
218	1.0	159	0.8	43	1.0	999	0.7	428	1.0	18,276	1.0	870	0.4	Utah
1,032	5.1	457	2.4	165	3.7	3,206	2.3	1,087	2.5	72,248	3.7	29,259	12.4	**TOTAL, Mountain**
359	1.8	594	3.1	71	1.6	3,958	2.9	1,644	3.8	38,829	2.0	3,002	1.3	Washington
269	1.3	205	1.1	44	1.0	1,392	1.0	686	1.6	24,979	1.3	1,809	0.8	Oregon
2,314	11.4	2,169	11.4	680	15.4	19,089	13.9	5,549	12.8	254,347	13.2	14,858	6.3	California
2	–	1	–	3	0.1	360	0.3	–	–	4,960	0.3	3	–	Alaska
28	0.1	22	0.1	10	0.2	705	0.5	101	0.2	12,850	0.7	8	–	Hawaii
2,972	14.6	2,991	15.8	808	18.3	25,504	18.6	7,980	18.4	335,965	17.5	19,680	8.3	**TOTAL, Pacific**

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